To Anonymous Reviewer #1: (Comment ID:acp-2020-60-RC1)

Dear Reviewer,

Thank you very much for carefully reviewing our manuscript. The constructive and thoughtful comments have helped us a lot to improve the paper. Following these suggestions, we have taken a lot of efforts to optimize the structure and to make the writing more concise and clear. Please find below the comments in blue italics and our responses in black and the changes in bold.

Responses to general comments:

In this manuscript, the measurements obtained during the Dust Aerosol Observation-Kashi campaign were employed in radiative transfer model and the estimations were improved by considering the actual measured atmospheric profiles and diurnal variations of land surface albedo. Direct aerosol solar radiative forcing of dust aerosols was analyzed based on comprehensive parameters and numerical models. The effects of data assimilations on estimating the radiative forcing effects were also explored. However, the manuscript was poorly worded, thus making me confused. The manuscript needs to structure writing accurately to produce proper paragraphs with clear topics. Major revisions are necessary before the manuscript is finally accepted for publication.

Reply: We thank the reviewer for the constructive criticisms that have helped us to improve our manuscript. We have worked hard on optimizing the structure of the manuscript. In the revised manuscript, we reorganized some sections:

1) subsection **"2.1 Experimental site and instrumentation" was divided into "2.1 Observation site" and "2.2 Instrumentation"**;

2) subsection **"2.2 Aerosol properties during the DAO-K campaign" was incorporated into subsection " 4.1 Aerosol solar radiative forcing and efficiency"**;

3) subsection **"3.3.3 Experimental setup" was rephrased as "3.3.3 Model setup"** to avoid confuse with the subsection of " Instrumentation";

4) section **"4 Results and Discussion" was changed to "4 Results of radiative transfer simulations"**;

5) subsection **“4.3 Comparisons and validation” was isolated from section 4 and changed to “5 Comparison with WRF-Chem simulations”** to avoid too much contents in section 4;

6) subsection **“4.3.1 Comparison between radiative transfer simulations and AERONET results” was renamed as “4.3 Difference from AERONET products”**, and was moved to follow the section 4.2 to state and discuss the results of radiative transfer model simulations together.

The new structure contains 6 parts: 1) Section “1 Introduction” begins with the introduction of background and significance, current status and problems, as well as research mentality and content of this manuscript. 2) Section “2 Dust Aerosol Observation-Kashi field campaign” gives a brief introduction of the DAO-K field campaign, and an overview of the multi-source observations and data. 3) Section “3 Estimation of aerosol solar radiative forcing” describes the methods to estimate *ASRF* by improving the inputs of atmospheric profiles and land surface albedo in RT simulation, and by employing data assimilation in the WRF-Chem simulation. 4) Section “4 Results of radiative transfer simulations” presents the results of *ASRF* simulated by RT model during the field campaign and for some specific cases. The influences of the atmosphere and surface conditions on the results are discussed. The difference from the corresponding AERONET operational products are also analyzed. 5) Section “5 Comparison with WRF-Chem simulations” gives direct comparison between the RT and WRF-Chem model simulations. Both the model simulations are evaluated based on the simultaneous irradiance measurements. 6) “Summary and conclusions” are given in Section 6. We believe that the new structure is more concise and understandable. We hope our revisions have satisfactorily addressed these issues.

Responses to specific comments:

1. Section 1, this part should introduce the research background and significance, current status, concealed problems, as well as research mentality and content of this manuscript. Nevertheless, the introduction of this manuscript is inundated with accumulation of literatures rather than sublimation of these research results. The authors need survey more literatures in recent five years and then summarized them.

Reply: Thank you for the frank comments and helpful suggestions. Following the suggestions, we have spent a lot of time to review and summarize related literatures. And on that basis we restructured the "introduction" section and clarify the research background and significance, current status, concealed problems, as well as research mentality and content of this study. We have made a number of changes in these respects. Major revisions concentrated in the second and third paragraphs:

"**As one of the largest sandy deserts in the world, the Taklimakan Desert located in the Xinjiang Uygur Autonomous Region of China is a main source region of Asian dust (Huang et al., 2009), which influences not only surrounding areas such as the Tibetan Plateau (Liu et al., 2008; Chen et al., 2013; Yuan et al., 2019), but also wide regions in Eastern Asia (Mikami et al., 2006; Liu et al., 2011b; Yuan et al., 2019), even North America and Greenland through long-range transports across the Pacific Ocean (Bory et al., 2003; Chen et al., 2017; Liu et al., 2019). An accurate assessment of the Taklimakan aerosol solar radiative forcing (*ASRF*, defined as the difference of the net solar irradiance with and without aerosols presence) is important to evaluate regional and global climate changes. However, simulations by different models with different observation inputs varied widely in literatures. Huang et al. (2009) employed the Fu-Liou RT model to simulate the Taklimakan *ASRF* during the dust episodes in the summer of 2006, and reported that the dust particles result in average daily mean SW warming of 14 W m^{-2} at the top of atmosphere (TOA), atmospheric warming of 79 W m^{-2}, and surface cooling of -65 W m^{-2}. Sun et al. (2012) adopted the RegCM4 simulations and reported both negative *ASRF* (i.e., cooling effects) of dust particles at the TOA and bottom of atmosphere (BOA) with the strongest values in spring during 2000~2009 period, reaching up to -4 W m^{-2} and -25 W m^{-2} in the Taklimakan Desert region, respectively. Li et al. (2018) also reported the negative multi-year average SW aerosol radiative forcing of -16 W m^{-2} at the TOA and -18 W m^{-2} at the BOA at the edge of Taklimakan Desert, Kashi station based on the SBDART simulations. The simulated results of dust aerosol radiative forcing have rarely been confirmed, especially in the Taklimakan Desert (Xia et al., 2009). Performances of various models sometimes were evaluated against the observations of aerosol optical depth (*AOD*), aerosol extinction profile, single scattering albedo (*SSA*), and particle size distribution (Zhao et al., 2010; Chen et al., 2014). Nevertheless, comparison of irradiance is indispensable to provide direct evidence for corroborating the *ASRF* simulated results.**"

“**An intensive dust field campaign is essential for comprehensive investigating the optical, physical, chemical, and radiative properties of dust aerosol particles over Taklimakan Desert. As such, one of the goals of the Dust Aerosol Observation-Kashi (DAO-K) field campaign is to provide high quality dataset on aerosol in this region to obtain accurate assessment of the Taklimakan aerosol solar radiative forcing…**”

Please find them in the section “1 Introduction” in the revised manuscript.

References:

Bory, A. J., Biscaye, P. E., and Grousset, F. E.: Two distinct seasonal Asian source regions for mineral dust deposited in Greenland (NorthGRIP), Geophys. Res. Lett., 30, 1167, doi:10.1029/2002GL016446, 2003.

Chen, S., Huang, J., Zhao, C., Qian, Y., Leung, L. R., and Yang, B.: Modeling the transport and radiative forcing of Taklimakan dust over the Tibetan Plateau: A case study in the summer of 2006, J. Geophys. Res. Atmos., 118, 797-812, doi:10.1002/jgrd.50122, 2013.

Chen, S., Zhao, C., Qian, Y., Leung, L. R., Huang, J., Huang, Z., Bi, J., Zhang, Y., Shi, J., Yang, L., Li, D., and Li, J.: Regional modeling of dust mass balance and radiative forcing over East Asia using WRF-Chem, Aeolian Research, 15, 15-30, http://dx.doi.org/10.1016/j.aeolia.2014.02.001, 2014.

Chen, S., Huang, J., Li, J., Jia, R., Jiang, N., Kang, L., Ma, X., and Xie, T.: Comparison of dust emissions, transport, and deposition between the Taklimakan Desert and Gobi Desert from 2007 to 2011. Science China Earth Sciences, 60(1), 1338-1355, doi:10.1007/s11430-016-9051-0, 2017.

Huang, J., Fu, Q., Su, J., Tang, Q., Minnis, P., Hu, Y., Yi, Y., and Zhao, Q.: Taklimakan dust aerosol radiative heating derived from CALIPSO observations using the Fu-Liou radiation model with CERES constraints, Atmos. Chem. Phys., 9, 4011-4021, doi:10.5194/acp-9-4011-2009, 2009.

Li, Z. Q., Xu, H., Li, K. T., Li, D. H., Xie, Y. S., Li, L., Zhang, Y., Gu, X. F., Zhao, W., Tian, Q. J., Deng, R. R., Su, X. L., Huang, B., Qiao, Y. L., Cui, W. Y., Hu, Y., Gong, C. L., Wang, Y. Q., Wang, X. F., Wang, J. P., Du, W. B., Pan, Z. Q., Li, Z. Z., and Bu, D.: Comprehensive Study of Optical, Physical, Chemical, and Radiative Properties of Total Columnar Atmospheric Aerosols over China: An Overview of Sun-Sky Radiometer Observation Network (SONET) Measurements, Bulletin of the American Meteorological Society, 99, 739-755, doi:10.1175/BAMS-D-17-0133.1, 2018.

Liu, L., Guo, J., Gong, H., Li, Z., Chen, W., Wu, R., Wang, L., Xu, H., Li, J., Chen, D., and Zhai, P.: Contrasting Influence of Gobi and Taklimakan Deserts on the Dust Aerosols in Western North America. Geophysical Research Letters, 46(15), 9064-9071, doi:10.1029/2019GL083508, 2019.

Liu, J., Zheng, Y., Li, Z., Flynn, C., Welton, E. J., and Cribb, M.: Transport, vertical structure and radiative properties of dust events in southeast China determined from ground and space sensors, Atmospheric Environment, 45(35), 6469-6480, doi:10.1016/j.atmosenv.2011.04.031, 2011b.

Liu, Z., Liu, D., Huang, J., Vaughan, M., Uno, I., Sugimoto, N., Kittaka, C., Trepte, C., Wang, Z., Hostetler, C., and Winker, D.: Airborne dust distributions over the Tibetan Plateau and surrounding areas derived from the first year of CALIPSO lidar observations, Atmos. Chem. Phys., 8, 5045–5060, doi:10.5194/acp-8-5045-2008, 2008.

Mikami, M., Shi, G., Uno, I., Yabuki, S., Iwasaka, Y., Yasui, M., Aoki, T., Tanaka, T.Y., Kurosaki, Y., Masuda, K., Uchiyama, A., Matsuki, A., Sakai, T., Takemi, T., Nakawo, M., Seino, N., Ishizuka, M., Satake, S., Fujita, K., Hara, Y., Kai, K., Kanayama, S., Hayashi, M., Du, M., Kanai, Y., Yamada, Y., Zhang, X.Y., Shen, Z., Zhou, H., Abe, O., Nagai, T., Tsutsumi, Y., Chiba, M., and Suzuki, J.: Aeolian dust experiment on climate impact: An overview of Japan-China joint project ADEC, Global and Planetary Change, 52, 142-172, doi:10.1016/j.gloplacha.2006.03.001, 2006.

Sun, H., Pan, Z., and Liu, X.: Numerical simulation of spatial-temporal distribution of dust aerosol and its direct radiative effects on East Asian climate, J. Geophys. Res., 117, doi:10.1029/2011JD017219, 2012.

Xia, X., and Zong, X.: Shortwave versus longwave direct radiative forcing by Taklimakan dust aerosols, Geophysical Research Letters, 36(7), L07803, doi:10.1029/2009GL037237, 2009.

Yuan, T., Chen, S., Huang, J., Wu, D., Lu, H., Zhang, G., Ma, X., Chen, Z., Luo, Y., and Ma, X.: Influence of Dynamic and Thermal Forcing on the Meridional Transport of Taklimakan Desert Dust in Spring and Summer. Journal of Climate, 32(3), 749-767, DOI: 10.1175/JCLI-D-18-0361.1, 2019.

Zhao, C., Liu, X., Leung, L. R., Johnson, B., Mcfarlane, S. A., Gustafson, W. I., Fast, J. D., and Easter, R. C.: The spatial distribution of mineral dust and its shortwave radiative forcing over North Africa: modeling sensitivities to dust emissions and aerosol size treatments, Atmos. Chem. Phys., 10, 8821-8838, doi:10.5194/acp-10-8821-2010, 2010.

2. Section 2 and 3, the authors seem to be drowned by abundant resources and avoid stringing them together to form a system. Some descriptions should be streamlined. The outline and structure of this manuscript should be reorganized.

Reply: Thank you also for pointing out these issues on the structure and the descriptions in Sections 2 and 3. We have made a number of changes in these respects.

First of all, as mentioned in the responds to the general comments, we restructured section 2 and rephrased the title of subsection 3.3.3 to make the structure more clear and compact: 1) subsection **"2.2 Aerosol properties during the DAO-K campaign" was moved out from this section**; 2) subsection **"2.1 Experimental site and instrumentation" was divided into "2.1 Observation site" and "2.2 Instrumentation"**; 3) subsection **"3.3.3 Experimental setup" was rephrased as "3.3.3 Model setup"** to avoid confuse with the subsection of "Instrumentation".

Secondly, we **modified the subsection "2.1 Observation site"** to explain why the experimental site was selected in Kashi instead of other main source region of Asian dust (e.g., Gobi Desert) and the representativeness of the experimental period to study the dust radiative forcing effects. Fig. 1 was also edited to focus on the location of experimental site.

Finally, we **reorganized Table 1 in subsection "2.2 Instrumentation" to summarize the parameters and instruments in three groups (i.e., applications in radiative transfer simulation, WRF-Chem simulation, as well as evidences and validation)**. The first two groups of parameters work as model inputs in section 3 (i.e., inputs of radiative transfer simulation and WRF-Chem model simulation, respectively). **Correspondingly, the introductions of experimental apparatus and data in this subsection were sorted into three groups and were arranged in three paragraphs**: 1) measurements of main data of aerosol properties (including sun-sky radiometer, continuous particulate monitor, and ambient air quality continuous automated monitoring system); 2) measurements of ancillary parameters of surface albedo and the vertical structure (including sounding balloons, OMI/Aura, MODIS/Terra+Aqua, pyrheliometer and pyranometers); 3) measurements of ancillary evidences of dust and cloud layers (including LILAS lidar and all sky view camera). The descriptions of each group contained data processing, quality control, and applications in this study. **Some detailed descriptions about the calibration of the sun-sky radiometers were removed to make the main line more concise.** Please find them the new subsection "2.2 Instrumentation" in the revised manuscript.

In these ways we hope to have tightened the structure and optimized the descriptions of the Section 2 and 3.

3. Section 2.1, this part should explain why the experimental site was selected in Kashi instead of the local aerosol properties, such as the representativeness or speciality in studying aerosol-related issues.

Reply: In response to the above comment (specific comment 2) we divided subsection"2.1 Experimental site and instrumentation" into two subsections "2.1 Observation site" and "2.2 Instrumentation" to make this part expressed in much cleaner, more structured manner. Following this comment, we have revised the subsection on experimental site so that the specialitis of aerosol property and aerosol radiation effect at Kashi site are more carefully introduced:

"**In addition to the Kashi station near the Taklimakan Desert, SONET also maintains two dust aerosol observation stations (i.e., Zhangye and Minqin stations) in the Gobi Desert which is another important source of Asian dust. Although some studies reported that the dust generated in Taklimakan Desert exerts a less influence on long-range downstream regions due to the unique terrain and low-level background wind climatology compared to those in Gobi Desert (Chen et al., 2017; Liu et al., 2019), Taklimakan Desert is more representative to study the effects of dust aerosol solar radiative forcing on local region than the Gobi Desert because of its huge dust emission capability (Chen et al., 2017).**"

"**According to the SONET long-term measurements from 2013, the Kashi site is frequently affected by dust, where the multi-year average *AOD* is up to 0.56±0.18 at 500 nm; moreover, the Ångström exponent (*AE*, 440~870 nm) and fine-mode fraction (*FMF*, 500 nm) at Kashi are the lowest (with the multi-year average values of 0.54±0.27 and 0.40±0.14, respectively) among all 16 sites within SONET around China (Li et al., 2018). In contrast, the multiyear average *AOD*s (500 nm) at Zhangye (0.28±0.11) and Minqin (0.26±0.11) are only half of that at Kashi or less (Li et al., 2018). Meanwhile, their average values of *AE* and *FMF* are also greater than those at Kashi (Li et al., 2018). They all imply coarse particles are more dominant in the Taklimakan Desert in comparison with the Gobi Desert.**"

Please find them in the subsection "2.1 Observation site" in the revised manuscript.

References:

Chen, S., Huang, J., Li, J., Jia, R., Jiang, N., Kang, L., Ma, X., and Xie, T.: Comparison of dust emissions, transport, and deposition between the Taklimakan Desert and Gobi Desert from 2007 to 2011. Science China Earth Sciences, 60(1), 1338-1355, doi:10.1007/s11430-016-9051-0, 2017.

Li, Z. Q., Xu, H., Li, K. T., Li, D. H., Xie, Y. S., Li, L., Zhang, Y., Gu, X. F., Zhao, W., Tian, Q. J., Deng, R. R., Su, X. L., Huang, B., Qiao, Y. L., Cui, W. Y., Hu, Y., Gong, C. L., Wang, Y. Q., Wang, X. F., Wang, J. P., Du, W. B., Pan, Z. Q., Li, Z. Z., and Bu, D.: Comprehensive Study of Optical, Physical, Chemical, and Radiative Properties of Total Columnar Atmospheric Aerosols over China: An Overview of Sun-Sky Radiometer Observation Network (SONET) Measurements, Bulletin of the American Meteorological Society, 99, 739-755, doi:10.1175/BAMS-D-17-0133.1, 2018.

Liu, L., Guo, J., Gong, H., Li, Z., Chen, W., Wu, R., Wang, L., Xu, H., Li, J., Chen, D., and Zhai, P.: Contrasting Influence of Gobi and Taklimakan Deserts on the Dust Aerosols in Western North America. Geophysical Research Letters, 46(15), 9064-9071, doi:10.1029/2019GL083508, 2019.

4. Lines 85-86, 'the Ångström exponent (AE, 440~870 nm) and fine-mode fraction (FMF) at Kashi are the lowest among all sites in China' What is the scientific value of this sentence? And it needs strong literature to support.

Reply: We changed this sentence into:

"**…moreover, the Ångström exponent (*AE*, 440~870 nm) and fine-mode fraction (*FMF*, 500 nm) at Kashi are the lowest (with the multi-year average values of 0.54±0.27 and 0.40±0.14, respectively) among all 16 sites within SONET around China (Li et al., 2018).**"

Please find it in the subsection "2.1 Observation site" in the revised manuscript. The scientific values of the multi-year average *AE* and *FMF* have been provided. The literature was also added.

References:

Li, Z. Q., Xu, H., Li, K. T., Li, D. H., Xie, Y. S., Li, L., Zhang, Y., Gu, X. F., Zhao, W., Tian, Q. J., Deng, R. R., Su, X. L., Huang, B., Qiao, Y. L., Cui, W. Y., Hu, Y., Gong, C. L., Wang, Y. Q., Wang, X. F., Wang, J. P., Du, W. B., Pan, Z. Q., Li, Z. Z., and Bu, D.: Comprehensive Study of Optical, Physical, Chemical, and Radiative Properties of Total Columnar Atmospheric Aerosols over China: An Overview of Sun-Sky Radiometer Observation Network (SONET) Measurements, Bulletin of the American Meteorological Society, 99, 739-755, doi:10.1175/BAMS-D-17-0133.1, 2018.

5. Section 2.2, 'aerosol properties during the DAO-K campaign' is part of the 'Results', so I suggest moving it to Section 4.

Reply: We agree with this point and have **moved the contents "aerosol properties during the DAO-K campaign" to section "4 Results of radiative transfer simulations"**. We realized that putting this part in section "2 Dust Aerosol Observation-Kashi field campaign" made the structure less understandable after the reviewer pointed it out. The reason being that in the previous manuscript these aerosol properties were input parameters for model simulations then were presented before the section "3 Estimation of aerosol solar radiation forcing". Following this suggestion, we decided to include this part in the section of results (i.e., "4 Results of radiative transfer simulations"). We also reduced the descriptions on aerosol properties during the DAO-K campaign and focused on the aerosol properties relating to solar radiative forcing and efficiency. Please find them in the first paragraph in the subsection "4.1 Aerosol solar radiative forcing and efficiency".

6. The structure of the manuscript makes me feel that some parts are more or less irrelevant to the title 'Solar radiative forcing of aerosol particles near the Taklimakan desert during the Dust Aerosol Observation-Kashi campaign in Spring 2019'. Too much attention was spent on Section 4.3.

Reply: The improvements of dust radiative forcing estimation and the evaluation of the model results are the main points of this manuscript. We recognize that such improvement of solar radiative forcing estimation and the comprehensive evaluations of model results in the manuscript may provide meanings for dust radiative forcing research in different regions and also can be extended to other kind of aerosol particles. Besides structuring contents into a more understandable format (see the reply to the general comments), we changed the title into "**Aerosol solar radiative forcing near the Taklimakan Desert based on radiative transfer and regional meteorological simulations during the Dust Aerosol Observation-Kashi campaign**" to make the topic more clearly and completely to be expressed.

To avoid too much contents in section 4 and to highlight the comparison and evaluation of the radiative transfer and WRF-Chem simulations in the manuscript, **subsection "4.3 Comparisons and validation" was isolated from section 4 and changed to "5 Comparison with WRF-Chem simulations".** The old subsection "4.3.1 Comparison between radiative transfer simulations and AERONET results" was renamed as "4.3 Difference from AERONET products", and was moved to follow the section 4.2 to state and discuss the results of radiative transfer simulations together.

Responses to technical comments:

1. Line 17, 'are improved by' should be changed to 'were improved by'.

Reply: **Changed as suggested**. Please see line 17 in the revised manuscript.

2. Line 40, 'it is a challenging' should be changed to 'it is challenging' or 'it is a challenge'.

Reply: It has been **changed to "it is still challenging"**. Please see line 39 in the revised manuscript.

3. Line 41, add 'the' before 'high surface albedo over desert'.

Reply: **Added as suggested.** Please see line 40 in the revised manuscript.

4. Line 42, I suggested replacing the sentence 'Numerous efforts have investigated…' with 'Numerous efforts have been undertaken to investigate…'.

Reply: **Replaced as suggested.** Please see lines 34-35 in the revised manuscript.

5. Line 52, 'have relatively small inter-annual variation' should be changed to 'had relatively small inter-annual variation'.

Reply: **Changed as suggested.** Please see lines 101-102 in the revised manuscript.-

6. Line 53, 'According to WRF-Chem simulations' should be changed to 'According to the WRF-Chem simulations'.

Reply: **The sentence has been removed in the revised manuscript.**

7. Line 85, the comma before 'moreover' should be changed to semicolon.

Reply: **Changed as suggested.** Please see line 94 in the revised manuscript.

8. Line 239, 'includes' should be changed to 'included'.

Reply: **Changed as suggested.** Please see line 249 in the revised manuscript.

9. Line 315, 'Globally' should be changed to 'Generally'.

Reply: **Changed as suggested.** Please see line 345 in the revised manuscript.

10. Line 433, 'for it will damage the surface-layer particulate results' should be changed to 'for that it will damage the surface-layer particulate results'.

Reply: **Changed as suggested.** Please see lines 460-461 in the revised manuscript.

11. I suggest deleting some acronyms, especially the phrases only appear once. Too many acronyms make the article chaotic.

Reply: Some less common acronyms, like **" TD" (Taklimakan Desert), " LOA" (Laboratoire d'Optique Atmosphérique), " CNEMS" (China National Environmental Monitoring Center), "BEC" (background error covariance), were deleted** in the revised manuscript.