## Response to Anonymous Referee #1

**Comments to the Author**

**General comments**

**In this paper, the spatial and temporal evolution of desert dust aerosols over South-East Asia has been systematically investigated based on CALIPSO since it can provide much information about aerosols. However, I'm interesting to see this paper published before revised as below suggestion.**

The authors would like to thank the reviewer for the interesting and at the same time substantial comments and suggestions. We tried, and did our best, to incorporate the most suitable proposed changes and corrections in the revised manuscript, aiming to the improvement of the presented paper.
Following, you will find our responses that are addressed to the Editorial board and the reviewers too.

**Specific comments**

**1. Page 1, Line 1: "Dust aerosols have a significant role on climate through the direct radiative effect of absorption and scattering of solar and thermal terrestrial radiation".**
**I think you should add the reference:**

- **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, https://doi.org/10.5194/acp-9-4011-2009, 2009.**
- **Chen, SiYu, JianPing Huang, JingXin Li, Rui Jia, NanXuan Jiang, LiTai Kang, XiaoJun Ma, and TingTing Xie. 2017. "Comparison of Dust Emissions, Transport, and Deposition between the Taklimakan Desert and Gobi Desert from 2007 to 2011." Science China-Earth Sciences 60 (7):1338–55. https://doi.org/10.1007/s11430-016-9051-0.**

We agree with the reviewer that the manuscript and the discussion would improve by including the recommended references. References are added in the manuscript.

**2. In the paragraph 1, the semi-effect of dust should be also added. The effect can be seen from the references:**
**Huang, Jianping, Bing Lin, Patrick Minnis, Tianhe Wang, Xin Wang, Yongxiang Hu, Yuhong Yi, and J. Kirk Ayers. 2006. "Satellite-Based Assessment of Possible Dust Aerosols Semi-Direct Effect on Cloud Water Path over East Asia." Geophysical Research Letters 33 (19):L19802. https://doi.org/10.1029/2006GL026561.**

We agree with the reviewer that the manuscript and the discussion would improve by including the recommended references. References are added in the manuscript.

**3. Line 10: “airborne mineral dust is considered a significant atmospheric aerosol contributor”, should be corrected into “...considered as a...”**

Corrected.

**4. Page 2, Line 29-32: ”although passive satellite sensors provide information on the column properties of aerosols with adequate spatial and temporal resolution, they are bound to certain limitations, the major limitation being the lack of information on the three-dimensional distribution (vertical profile) of aerosols in the atmosphere, an important information for the assessment of the aerosols radiative forcing on climate as well as their contribution as IN and CCN (IPCC 2013).” This sentence is too long to understand it means, please rewrite it.**

The long sentence was re-written, in order to be easier to understand: “Although passive satellite sensors provide information on the column properties of aerosols with adequate spatial and temporal resolution, they are bound to certain limitations. The major limitation is the lack of aerosol information on the three-dimensional distribution (vertical profile), which consist of an important parameter for the assessment of the aerosols radiative forcing on climate as well as their contribution as IN and CCN (IPCC 2013).”.

**5. Page 4, line 10: I think you should delete this words: “in order to discriminate the detected atmospheric features types into subtypes”, because we have known the goal of the classification algorithm before this sentence.**

The authors are of the opinion that this section consists a methodology bridge to the pure-dust product, between the CALIPSO algorithm and aerosol subtype classification and the decoupling of the pure-dust component from the classified as dust and polluted dust aerosol layers by CALIPSO . Towards this goal and since the methodology section largely is based on the classification algorithm, the authors considered that these lines should not be deleted, but under consideration of the recommendation of the reviewer they are modified to:
“The Level-2 (L2) product consists the high-level quality products. More specifically, CALIPSO L2 algorithm classifies the detected layers into characteristic classes (Vaughan et al., 2009), namely into clear air, cloud, aerosol, stratospheric, surface, subsurface, totally attenuated or invalid feature types. The classification algorithm (Omar et al., 2009) utilizes the depolarization ratio and the magnitude of the attenuated backscatter signal, the height of the aerosol layers and the characteristics of the Earth’s surface along the CALIPSO footprint (desert, ocean, snow/ice) in order to discriminate the detected atmospheric features types into subtypes“.

**6. Page 4, line 14: the “2ox5o grid resolution” should be corrected into “2$^{o}$x5$^{o}$”.**

Corrected.

**7. Page 4, line 17: "1ox1o" need to be corrected. The whole paper should be checked again.**

Corrected. The whole paper was checked again.

**8. Page 6, line 18: since you have said that the daytime minimum and nighttime minimum, what does the "minimum detectable AOD of 0.005" mean?**

According to the reviewer's recommendation the text is corrected to: "Regarding the uncertainties of the products, CALIOP L2 V3 is characterized by daytime minimum detectable backscatter of 0.0017±0.0003 $km^{-1}sr^{-1}$, nighttime minimum detectable backscatter of 0.0008±0.0001 $km^{-1}sr^{-1}$ and AOD of 0.005 (based on the minimum CALIOP 532 nm channel detection sensitivity, Winker et al., 2009)".

**9. Page 4, line 24: what does the "SAMUM" mean? Please write the full name.**

The text is modified according to the reviewer's recommendation: "During the SAharan Mineral dUst experiMent (SAMUM) 1 and 2 campaigns Saharan dust ...".

**10. Page 4, line 51: in this paragraph you introduce the methods of distinguish pure dust and non-dust. However, I still don't know the differences of the CALIPSO product of dust and polluted dust with the pure dust and non-dust. Since we can directly derive the dust extinction coefficient and profiles from the product, why don't you use it? And what about merits of the method to select the pure dust? What's the differences of the pure dust and dust products directly from CALIPSO L2?**

The CALIPSO V3 aerosol classification algorithm classifies the detected aerosol features as marine, dust, clean continental, polluted continental, polluted dust and smoke (Omar et al., 2009). Typical dust particle depolarization ratio values measured with lidars in field campaigns around the globe show values between 0.27 and 0.35 at 532 nm. Furthermore, the measurements show little variation independently of the source region, (e.g., Ansmann et al., 2011; Sakai et al., 2000; Liu et al., 2008b; Freudenthaler et al., 2009; Groß et al., 2011; Burton et al., 2013; Groß et al., 2013; Groß et al., 2015; Illingworth et al., 2015). Based on the dust depolarization ratio, a methodology has been established to discriminate the pure-dust component from mixtures of dust and non-dust aerosol layers (Tesche at al. 2009). In this methodology both the CALIPSO dust and polluted dust aerosol types are treated as mixtures of dust aerosols and non-dust aerosols. The methodology is applied and the final CALIPSO pure-dust product (the pure-dust component of the dust/polluted dust layers of CALIPSO) (Amiridis et al., 2013) are available to perform CALIPSO climatological studies (Marinou et al., 2017) and to develop interesting dust-related products (LIVAS-Amiridis et al., 2015).

**11. Page 5, line 30: please check this sentence of "The seasonal zonal distribution of the climatological and conditional dust extinction coefficient ($Mm^{-1}$)". If it's right to explain it.**

The reviewer is right, this was an editing error by the authors. The author's intension was to implement typographical symbol in order to introduce a list of CALIPSO products that would be used in the study and accordingly extensively discussed. Omitting the typographical symbol resulted in much confusion and we apologize for this mistake. The symbols have been restored, the list is clarified along with the sentence.

**12. Page 5, line30: I want to know whether the climatological dust extinction coefficient means the aerosol extinction without dust extinction coefficient since you write this sentence "This is accomplished by setting the dust extinction coefficient value of 0 km-1, for observations with non-dust aerosols". And the conditional dust product only has the dust extinction coefficient.**

The climatological extinction coefficient is computed by setting the extinction coefficient value of the non-dust aerosols to 0 $km^{-1}$, when averaging the profiles over a grid. The authors agree with the reviewer that this part of the manuscript was not clear, therefore it is re-written as follows:
"The climatological dust product is a measure of the average dust load over a geographical domain and is computed acknowledging only the contribution of the dust component in the atmosphere. Technically, this is accomplished by setting the extinction coefficient value of the non-dust aerosols to 0 $km^{-1}$, when averaging the profiles over a grid. The dust climatological product can be used for studies related to the contribution of dust to the total aerosol load over a period of time. In addition, the climatological dust product can be used in the evaluation of models related to dust transport and to radiative transfer models, in studies of dust-related physical processes (dust transport dynamics, CCN, IN), to investigate the effect of dust aerosols on ecosystems (dust deposition into the oceans) and to determine the dust aerosol load over highly industrialized and densely populated regions.
The conditional dust product is a measure of the average intensity of dust load over a geographical domain and is based explicitly on the dust profiles, hence ignoring completely non-dust aerosols. Technically, this is accomplished by setting the extinction coefficient value of the non-dust aerosols to not-a-number (NaN), when averaging the profiles over a grid. The conditional dust product is related to the intensity of the dust events."

**13. Page 7, line 33: what does the "N. China" mean?**

Corrected to: "Over N. China, for latitudes northern than 35° N, a similar pattern with respect to the features of dust contribution to the total aerosol load due to the dust aerosol emitted from the Taklimakan and Gobi deserts are observed".

**14. Page 8, line 11: from the figure 3, the differences of dust frequency in the four seasons are not clear, and the minimum in Fig. 3a is not obvious.**

Both the scale and the colormap of the dust frequency, CoM and TH are modified, according to the suggestion by the reviewer. Please see the figures below, before and after the adaptation of the figures.

**Before**

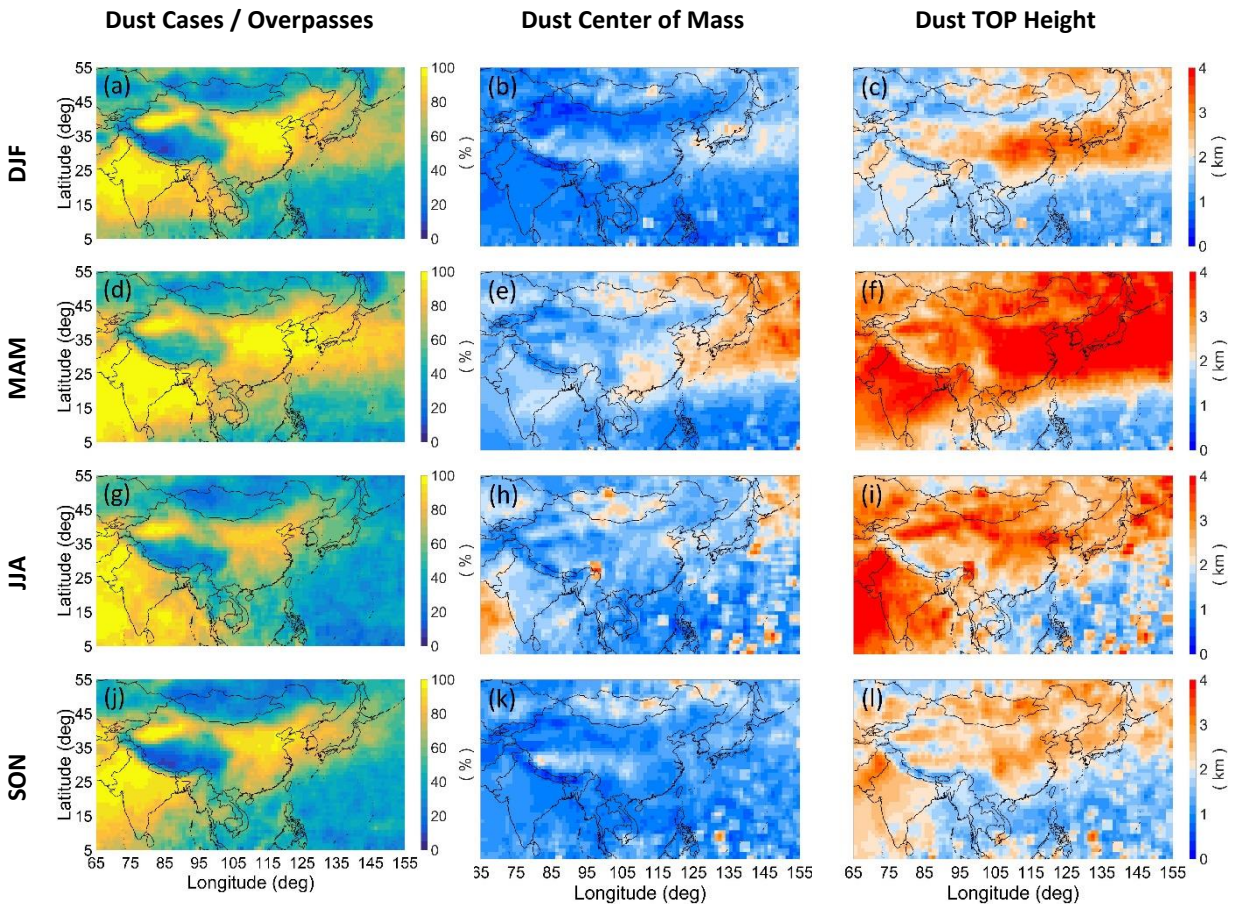
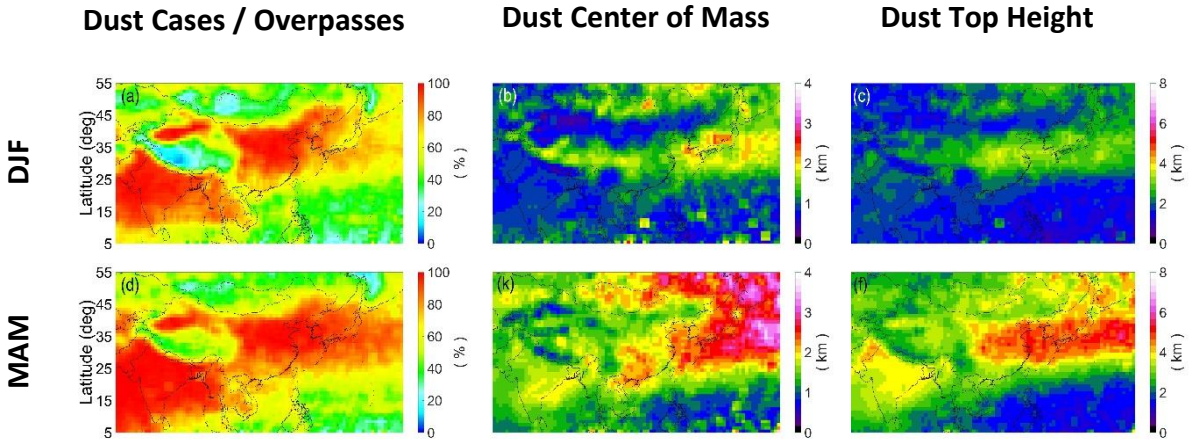



**Fig. 3: Spatial distribution of dust occurrence [%], climatological pure-dust CoM (Center of Mass) and dust TH (Top Height) in km a.g.l., for each season over the domain between 65°-155° E and 5°-55° N and for the period 01/2007-12/2015.**

**After**



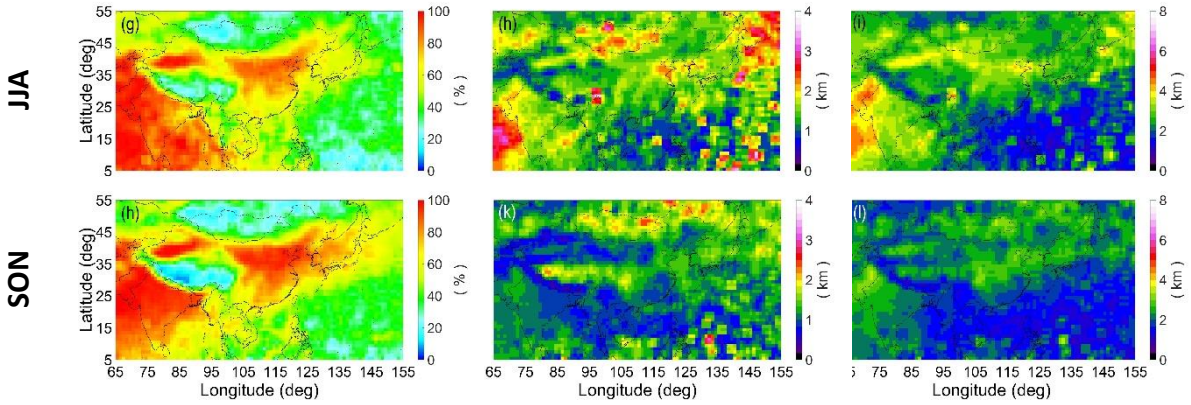



**Fig. 3: Spatial distribution of dust occurrence [%], climatological pure-dust CoM (Center of Mass) and dust TH (Top Height) in km a.g.l., for each season over the domain between 65°-155° E and 5°-55° N and for the period 01/2007-12/2015.**

## 15. Page 8, line 39: please explain the pattern of the dust transport since you said "however, the pattern reverses (Fig. 3i)"

Corrected to: "During MAM, dust particles emitted from the Taklimakan and Gobi deserts are transported over C. China and the Pacific Ocean, while at the same time significant long-range transport of dust aerosols emitted from Thar Desert is not-observed (Fig. 3f). During JJA, however, the pattern reverses, with longer range of dust particles transported from Thar Desert over the Indian Peninsula, the Arabian Sea and the Bay of Bengal, while no significant dust transport of dust aerosol emitted from Taklimakan Desert is observed (Fig. 3i)."