Response to Anonymous Referee #2

The paper by Proestakis et al. presents a 9-year climatology derived with mainly CALIOP measurements of the aerosol (dust) conditions over East and South Asia. The main focus is set on dust distribution but also non-dust aerosol is discussed. These novel results are thus of interest for atmospheric research and give a good overview of the dust distribution in this part of the world. Therefore in principle the paper is of interest for publication in ACP, however I recommend major revisions before it can be published. This is further explained below.

The authors would like to thank the referee for the interesting and at the same time substantial constructive comments and suggestions. We tried, and did our best, to incorporate the 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 as well.

Major comments

In my opinion the naming of the study area is misleading. Even though South-East Asia may not be a protected phrase, many people have a different understanding concerning the region called this way. See for example:
https://en.wikipedia.org/wiki/Southeast_Asia
Therefore, I recommend to find a better name for the study area (e.g. South and East Asia or whatever) to avoid confusion and change the title and text accordingly.

According to the reviewer's recommendation the name of the study area is changed from "Southeast Asia" to "South and East Asia", both in the title and the text.

The difference between the climatological and conditional dust product needs be more discussed in both, the methodology section (I just understood the difference when reading Marinou 2017 but as this is essential it should be explained more explicitly here), but also in the result section. The reader is left alone with contradictory statements, like for example the dust top height which seems to be completely different between the two products. Therefore it should be clearly discussed:
(1) Which product can be used for which purpose?
(2) Does it make sense to use this two different products, if yes why and for what?
(3) What we can learn from the two products presented here with respect to South and East Asia.

Both the "Data and Methodology" and the "Results" Sections have been revised and re-written according to the recommendation of the reviewer. To be more specific, (1) and (2) have been re-written and extended as follows:

The seasonal zonal distribution of the climatological and conditional dust extinction coefficient (Mm^{-1}).

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.

In addition to the above a Flowchart is provided according to the reviewer's suggestion in the end of the ""Data and Methodology" Section (comment 4.3).

(3) is additional included. In general the findings are summarized in "Summary and conclusions" Section, which is re-written.

Conclusion: The current conclusion is not very informative. Thus, it should be really overworked to highlight new things and discuss what lessons have been learned, i.e. what are new results or newly gathered knowledge or does your study just confirm former studies etc...

The authors agree with the reviewer, the conclusion section was re-written in order to provide more information and highlights of the study. Below we provide a part of the conclusion which was vastly rephrased and extended:

"In this work, CALIPSO is used to provide a multiyear 4-D climatology of desert dust aerosols over South and East Asia at a spatial resolution of 1ox1o deg grids. An optimized dust aerosol product, developed using CALIOP backscatter and particle depolarization ratio, along with a regional correction on dust lidar ratio suitable for Asian dust is used. The optimized product is utilized to provide the horizontal and vertical distribution along with the temporal evolution of dust aerosols over a 9-year period (01/2007-12/2015).

Regarding the horizontal distribution of Aerosol Optical Depth (AOD), Dust Aerosol Optical Depth (D_AOD) and Non-Dust Aerosol Optical Depth (Non-Dust AOD), our analysis shows similar patterns between all four seasons, although the magnitude of the observed features varies with season. High values of Non-Dust AOD are consistently observed over the heavily industrialized and densely populated regions of China and India (Non-Dust AOD > 0.5). In addition to the anthropogenic densely populated areas of South and East Asia, the major sources of dust aerosols, namely the Taklimakan, Gobi and Thar Deserts are clearly mapped through the systematic high D_AOD values throughout the year. The magnitude though of the D_AOD observed features is subject to high seasonality, ranging between D_AOD 0.2 during winter and higher than 0.6 during spring and summer seasons. Maximum activity of Gobi and Taklimakan deserts is observed during spring, while the highest activity of Thar Desert is

during summer. The seasonality of the dust transport pathways is additionally well-captured. Dust transport over the Indian Peninsula is more pronounced during spring and summer, while over China similar patterns of a persistent dust aerosol background is evident throughout the year, with a peak during spring when the dust transport across the Pacific Ocean is at its maximum.
Regarding the vertical distribution of dust aerosols, the Center of Mass (CoM), Top Height (TH) and the mean Dust Extinction Coefficient profiles (Climatological and Conditional) are implemented to provide, together with the horizontal distribution, the full three-dimensional structure of dust aerosols and the atmospheric dust transport pathways over the entire South and East Asia. Based on the synergy of CoM, TH and the CALIPSO dust extinction profiles two distinct dust transport pathways over South and East Asia are observed: a the Trans-Pacific belt between 25o and 45o N and a second one, extending from Thar Desert towards the Bay of Bengal and the Arabian Sea. Both zones of dust transport are subject to high seasonality. Highest dust aerosol transport from the Taklimakan Desert towards the Pacific Ocean is observed during spring, while dust aerosol transport from the desert of Thar and across the Indian Subcontinent is more pronounced during summer.
Regarding the temporal evolution of AOD and D_AOD between 01/2007 and 12/2015, the analysis showed statistically significant positive short-term AOD trends over the Indian Peninsula (0.01 yr-1), NW China (0.007 yr-1) and E China (0.01 yr-1), whereas our study shows negative short-term AOD trends over SE China (-0.007 yr-1). CALIPSO positive AOD trends are found over the broader central and eastern Indian Peninsula (0.01 yr-1). The CALIOP observed trends between 01/2007 and 12/2015 are generally in qualitative agreement with the derived MODIS AOD trends over large domains of South and East Asia, although the short-term trends disagree over specific regions. The CALIOP and MODIS trends though are interpreted and compared with caution, since the samples of the datasets are non-uniform. ”

Please check spelling and grammar intensively again. There are many sentences which are fractals, i.e. words are missing. Furthermore, many commas are missing, considering the bunch of co-workers this should be no problem.

The authors have gone through the entire manuscript again to check for spelling and grammar again. At this point the authors would like to thank the reviewer once more for the substantial contribution towards the direction of improving the overall manuscript.

Minor comments

Page 1.1: According to the reviewer’s recommendation the name of the study area is changed from “Southeast Asia” to “South and East Asia”, both in the title and the text.
Page 1.2: According to the reviewer’s suggestion, two sentences are used to simplify the initial sentence: “To distinguish desert dust from total aerosol load we apply a methodology developed in the framework of EARLINET (European Aerosol Research Lidar Network). The methods involves the use of particle linear depolarization ratio and updated lidar ratio values suitable for Asian dust, from multiyear CALIPSO observations (01/2007-12/2015).”
Page 1.3: Wavelength is included: “532 nm”.

Page 1.4: Suggestion is included.

Page 2.1: Suggestion is included, the text is modified accordingly.
Page 2.2: The text is corrected: from "Major dust Asian" to "Major Asian dust".
Page 2.3: According to the suggestion the text is modified: from "CALIOP measures total attenuated backscatter signals at …" to "CALIOP measures total attenuated backscatter at …"

Page 3.1: According to the suggestion the text is rephrased: "Using this classification they either did not take into consideration the dust component of the classified as, polluted dust aerosol subtype, or they defined as "dust" both the dust and polluted dust aerosol subtypes (hence including the non-dust component of polluted dust)".
Page 3.2: Suggestion is included.
Page 3.3: Suggestion is included: "… this new pure dust …".
Page 3.4: Suggestion is included: "… pure dust product …".
Page 3.5: The text is corrected: from "laser" to "lidar".
Page 3.6: Since according to the reviewer the sentence was not clear the text is rephrased to: "CALIOP transmits linear polarized light, while a telescope of 1 m diameter collects the backscatter component backscattered by the atmosphere.".

Page 4.1: The text is modified according to the reviewer's recommendation and the different feature type classes are included: "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."
Page 4.2: The manuscript is cross-checked and the aerosol subtype classification scheme is not explained before this part in the data and methodology section. Part of the paragraph though is rephrased: "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. The atmospheric features types classified as aerosols are further distinguished into specific aerosol subtypes (Clean Marine, Dust, Clean Continental, Polluted continental, Polluted Dust and Smoke)."
Page 4.3: According to the suggestion the following Flowchart, diagrammatic representation from the CALIPSO data to the Pure-Dust product and the Climatological/Conditional Dust products used in the study is added to the end of the "Data and Methodology" Section.

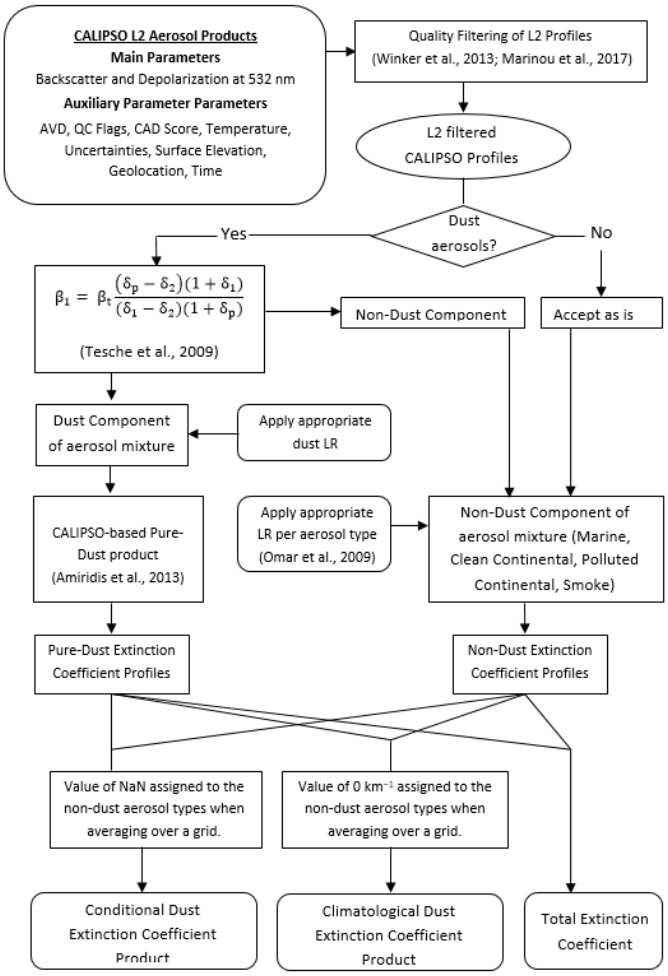


Fig. 2: Flowchart of the CALIPSO Pure-Dust, Conditional Dust Extinction Coefficient and Climatological Dust Extinction Coefficient products.

Page 4.4: The text is corrected: from "… with cloud observations are filtered from …" to "… with cloud observations are filtered out from …".
Page 4.5: According to the suggestion the text is modified: from "… value of the pure dust component, $\beta_{\perp}$ …" to "… value of the pure dust component in the aerosol mixture, $\beta_{\perp}$ …"
Page 4.6: According to the recommendation by the reviewer the following two references are added: "Omar et al., 2009".

Page 5.1: The authors agree with the reviewer that the paragraph in the beginning of the "Data and Methodology" section is confusing, therefore the entire paragraph was moved to the end of the "Introduction Section" at the part of the description of the study domain.
Page 5.2: According to the reviewer's recommendation the name of the study area is changed from "Southeast Asia" to "South and East Asia".
Page 5.3: The backscatter coefficient.
Page 5.4: The text is corrected: from "extinction coefficient" to "backscatter coefficient".

Page 5.5: The reviewer is right, this was an editing error. 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 discussed. Omitting the typographical symbol resulted in much confusion to both the reviewers and we apologize for this mistake. The symbols have been restored and the list is clarified along with the sentence.
Page 5.6: Done (major comment and comment 4.3).
Page 5.7: Done (major comment and comment 4.3).
Page 5.8: According to the reviewer's recommendation the sentence is modified to include which product: "Validation of the pure dust aerosol product against …".
Page 5.9: According to the reviewer's recommendation the sentence is modified to include the domain: "… observations over northern Africa and Europe show …".
Page 5.10: The sentence did not make sense since it is part of a list which was omitted. Corrected through the introduction of the list and the typographical symbols (comment 5.5).

Page 6.1: Full stop added.
Page 6.2: Wavelength is included: "532 nm".
Page 6.3: Discuss AOD uncertainty is approximately 100% close to the surface (Marinou et al., 2017).
Page 6.4: According to the suggestion from the reviewer the sentence "Additional, uncertainty which propagates into the D_AOD product is introduced due to the depolarization ratio of the non-dust aerosols, coupled into the polluted-dust aerosol subtype." is rephrased to: "In addition, as it is already mentioned, both aerosol types classifies by CALIPSO as dust or polluted dust are a mixture of a dust component and a non-dust component. Thus another source of uncertainty in the decoupling of the dust component from the total aerosol load is the lack of information regarding the non-dust component in the aerosol mixture, due to the low depolarization ratio values of the non-dust aerosol subtypes (Omar et al., 2009)."
Page 6.5: According to the suggestion from the reviewer the sentence "... the seasonal approach is selected ..." is rephrased to: "… in this section we present and discuss the horizontal distribution of aerosols and dust over South and East Asia per season."
Page 6.6: According to the suggestion from the reviewer the entire paper is homogenised. "ΔOD" is replaced to "Non-Dust AOD".

Page 7.1: Satellite-based remote sensing, both passive and active, is highly sensitive to the presence of clouds. Regarding CALIOP, the nadir-viewing lidar measurements and orbital characteristics of CALIPSO result in a low frequency of overpasses over each region and consequently the significant fewer observations with respect to passive sensors. Therefore, in order to provide meaningful climatologies on a regional scale, long-term and multiyear CALIOP observations are required. Even though over specific regions which are characterized of extensive cloud coverage of dense cloud (Bay of Bengal, Indonesia, N. Pacific Ocean), the number of observations in the sample is even sparser, due to attenuation in dense clouds. Therefore rare regional events are not well captured over regions of extensive cloud coverage, resulting in weighted values toward regions of less extensive cloud coverage (Winker et al., 2013).

Page 7.2: Indochina is a political and geographical correct term. Indochina, originally Indo-China, is a geographical term originating in the early nineteenth century and referring to the continental portion of the region now known as Southeast Asia. The name refers to the lands historically within the cultural influence of India and China, and physically bound by the Indian Subcontinent in the west and China in the north. It corresponds to the present-day areas of Myanmar, Thailand, Laos, Cambodia, Vietnam, and (variably) peninsular Malaysia and Singapore. See for example: https://en.wikipedia.org/wiki/Indochina
Page 7.3: According to the suggestion from the reviewer the sentence is modified to: "Over China similar geographical patterns in the horizontal distribution of aerosols are evident between all four seasons, with larger Non-Dust AOD values over the major sources of anthropogenic aerosols (Beijing, Shanghai, Guangzhou, Chongqing, Wuhan) such as urban clusters (Beijing, Shanghai, Guangzhou, Chongqing, Wuhan) (Kourtidis et al., 2015) and high D_AOD values over the deserts of Taklimakan and Gobi (Che et al. 2014, 2015)".
Page 7.4: Done (comment 7.3).
Page 7.5: Done (comment 7.3).
Page 7.6: Corrected: "… high D_AOD values …".
Page 7.7: For example to the north of the plateau of Tibet, during the period between March and May the strong surface winds which develop over the Mongolian Plateau create favourable mechanisms of extreme dust events (Bory et al., 2003; Yu et al., 2008). This feature is evident throughout the year, although more pronounced during spring. By activation of the deserts the authors mean the creating of favourable conditions for dust generation and injection in higher altitude in the atmosphere.

Page 7.8: The sentence is rephrased to: "Over China, for latitudes northern than 35o 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. More specific, a persistent dust aerosol background is evident during all seasons, with a peak during MAM (Fig. 3f)."
Page 7.9: Rephrased (comment 7.8).
Page 7.10: This is in line with previous studies, reporting rare events of dust transport over Himalayas (Huang et al., 2007; Liu et al., 2008b; Yumimoto et al., 2009). The region to the North of Taklimakan, Gobi and Mongolia is also characterized by low values of AOD and D_AOD, except during MAM (Fig. 3f, h). The high dust aerosol load observed to the east of the major dust aerosol source of Taklimakan (D_AOD values greater than 0.3) and the high percentage of D_AOD with respect to the total AOD indicate a strong eastward transport of both dust (Fig. 3f) and anthropogenic aerosols (Fig. 3g). The paragraph is modified accordingly.

Page 8.1: Both suggestions are implements, the a.g.l. is added to the figure caption and the common nomenclature are used.
Page 8.2: According to the reviewer's recommendation the name of the study area is changed from "Southeast Asia" to "South and East Asia".
Page 8.3: According to the recommendation by the reviewer we have included some numbers. More precisely the following part is added: "Lower frequencies of dust occurrence, which still exceed 70%, are also evident over east China and south-eastern

India. Conversely over Indochina and Indonesia the occurrence of dust is particularly low, especially during summer (Fig. 4g) and autumn (Fig. 4j). To be more specific, values of dust occurrence percentage between 50% and 60% over Thailand and Cambodia, 40% to 60% over Laos and Vietnam, ~60% over SE China, and lower than 40% over Malaysia and Philippines are observed, during JJA and SON.”.
Page 8.4: Comma added.
Page 8.5: “s” deleted.
Page 8.6: The authors are not sure in which paper the reviewer is referring to, though we suspect that the differences most probably are related to the definition of the TH and CoM, probably to differences in the above ground level or above sea level reported profiles, maybe to different seasonality, sensor detection limits, differences in the techniques applied, to different samples. There are just many factors that may result in the different observations.
Page 8.7: The sentence is rephrased according to the suggestion of the reviewer, since the meaning was not clear. The sentence is rephrased from: “In addition, the observed gradient in the horizontal distribution of D_AOD values between the sources and the Pacific Ocean (Fig. 3f), parallel to the ubiquitous dust layer and the high dust TH (Fig. 4f), are an indicator of the longer range of transport of lower concentration of dust particles.” to “In addition, a decreasing west-to-east D_AOD gradient is observed over N. China, between the dust sources over Taklimakan and Gobi and the Pacific Ocean (Fig. 3f). The decreasing gradient of TH is less pronounced during MAM, when dust aerosol are injected as high as 10 km height (a.s.l.) and transported longer distances over the Pacific Ocean (Fig. 4f).”.
Page 8.8: Comma added.
Page 8.9: Since according to the reviewer the meaning was not clear, the paragraph was rephrased accordingly: “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. 4f). During JJA, however, the pattern reverses, with longer range transport of dust particles 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. 4i).”.
Page 8.10: Sentence corrected (comment 8.9).
Page 8.11: “larger” is replaced by “higher” according to the recommendation by the reviewer.
Page 8.12: Adapted (comment 27.1).
Page 8.13: Comma deleted.
Page 8.14: “into” is replaced by “over” according to the recommendation by the reviewer.

Page 9.1: “the” deleted.
Page 9.2: Sentence is modified accordingly: “… provided in Table 1”.
Page 9.3: The pure dust component is of interest to regions where dust aerosols are present. In the domain of South and East Asia, such domains are East China and India. East China is affected from dust aerosol transport from the Taklimakan and Gobi, while India is affected from dust transport from Thar Desert and the Arabian Peninsula. The

significance of dust load is even larger due to the anthropogenic emissions of the densely populated provinces of China and the regions of India.

Page 9.4: Initially we had a column of the study domain, encompassing the different domains. In general, after initial submission, we have tried to move the individual figures as close to each other as possible, otherwise the individual plots won't exceed stamp size in the final paper and the reader won't be able to recognise a thing. Towards this need, we had to omit as much redundant information from the initial submission as possible, including the map plots which indicated the bands of interest, since the reader can take this information from Figure 1.

Page 9.5: Corrected: "The continuous and dashed lines correspond to the average elevation of the surface level and to the average maximum elevation respectively.".

Page 9.6: This threshold is arbitrarily selected to filter out low dust aerosol extreme cases scenarios in order to limit the influence of rare events on climatology. To be clearer, the following was added: of the pure dust climatological extinction coefficient, arbitrarily selected, in order to avoid presenting extreme rare events in high altitudes at the same time with climatological values close to the surface level

Page 9.7: Indeed the sentence "Regarding the Taklimakan Desert, this region is a very prolific arid area encompassed by Tarim Basin" is clarified to "Taklimakan Desert, consists a very arid area encompassed by Tarim Basin".

Page 10.1: Indeed, the reviewer is right, the sentence is modified accordingly: from "during MAM lofted of dust extinction coefficient ..." to "… during MAM dust aerosol layers are detected …".

Page 10.2: According to the opinion of the authors, the CoM should not be plotted together with the climatological dust extinction coefficient, and the reason is threefold. First of all, the purpose of the climatological dust product is to answer the question, which is the aerosol load over a specific region on a climatological basis, while the purpose of the CoM is to provide the climatological center of mass of the average dust profile. A rare example is related to a region where dust is never present. Over such a region the climatological dust profile is a well-defined profile of zeros. On the contrary, by mathematical definition, the CoM over such profile cannot be computed (NaN). The second reason is related to the representativeness. An example over the study domain of South and East Asia is the Himalayas orographic barrier. Extreme and very rare events of dust transport over Himalayas have been reported. The CoM plotted together with the climatological dust extinction coefficient profiles would create to the reader a misleading view of frequent dust transport over this region, due to the lack of the information of how many events are used to compute the profile and the CoM. The third reason is related to the fact that the CoM is always defined above ground level. Due to the complex surface orography of South and East Asia, the mean surface elevation of the used regions sometimes may be above the CoM. For example Tarim Basin, the basin that encompasses the Taklimakan Desert has an elevation approximately 2 km higher than the Taklimakan desert elevation. Thus during the non-active seasons the dust CoM would be below or very close to the mean Surface elevation of the region.

Page 10.3: Indeed, the sentence is modified accordingly from "... attributed the gravitational settling of aerosols and to dry and wet deposition (Colarco et al., 2003)."

to "... attributed to both dry and wet deposition processes that remove dust aerosol from the atmosphere (Colarco et al., 2003).".

Page 10.4: Indeed, the reviewer is right, the sentence is modified accordingly: from "MAM a lofted layer of dust climatological extinction coefficient up to 25 Mm^{-1} is observed ..." to "…MAM a lofted layer of dust aerosols that yields climatological extinction coefficient up to 25 Mm^{-1} is observed …".

Page 10.5: The Climatological Total Extinction Coefficient close to the surface over the densely populated regions of East China, especially during MAM when a large component of the AOD is related to dust aerosols transported from Taklimakan and Gobi deserts is as high as 200 Mm^{-1}. For more information: de Leeuw, G., Sogacheva, L., Rodriguez, E., Kourtidis, K., Georgoulias, A. K., Alexandri, G., Amiridis, V., Proestakis, E., Marinou, E., Xue, Y., and van der A, R.: Two decades of satellite observations of AOD over mainland China, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2017-838, in review, 2017.

Page 11.1: The difference between climatological and conditional is improved and adapted and already discussed.

Page 11.2: "coefficient" deleted.

Page 12.1: Since according to the reviewer it was not clear through the sentence where the features of dust transport pathways are observed in Figure 6, the sentence is modified accordingly: "To the north and east of the Tibetan Plateau two distinct eastward pathways of dust transport are evident: (1) a northern flow that propagates towards the Yellow Sea and the Pacific Ocean (Uno et al., 2009) (Fig. 6f, g) and (2) a southern flow that occurs over central China (Kuhlmann and Quaas, 2010) (Fig 6k, o)."

Page 12.2: Corrected. "Both transport pathways are observed at the middle and upper troposphere …".

Page 12.3: Indeed the authors agree with the reviewer that the paragraph was not written in a clear way to help the reader to navigate along the figures and easily absorb the information provided. Thus the entire paragraph was rewritten: "To the north and east of the Tibetan Plateau two distinct eastward pathways of dust transport are observed: (1) a northern flow that propagates towards the Yellow Sea and the Pacific Ocean (Uno et al., 2009) and (2) a southern flow that occurs over central China (Kuhlmann and Quaas, 2010). The northern flow is mostly evident during winter (Fig. 3d), while the southern transport pathway over C. China is more prominent during spring (Fig. 3h). Figure 6 provides information on the vertical distribution and depth of the two dust transport pathways. Both transport pathways are observed at the middle and upper troposphere, indicated by dust conditional coefficient values as high as 20 Mm^{-1}, observed at altitude up 10 km a.s.l. Another noticeable feature is that the vertical intensity of the transported dust aerosol plumes is subject to high spatial and seasonal variability. Decreasing values of both dust aerosol climatological and conditional values are observed with increasing distance from the dust sources of Taklimakan and Gobi deserts towards and over the Pacific Ocean.".

Page 12.4: Comment 12.3

Page 12.5: Comma deleted.

Page 12.6: Comment 12.3

Page 12.7: The reviewer is right. "(as discussed in Section Data and Methodology)" is added.
Page 12.8: According to the different particle depolarization values, a mean value of 0.03 value is used for the non-spherical aerosol types. This introduces uncertainties since the 0.03 is a mean value, ±0.01.
Page 12.9: "particle" added.
Page 12.10: Indeed the sentence is rephrased: "Figure 7 shows the vertical, horizontal and seasonal variability of the average particle depolarization ratio of the cases classified by CALIOP as dust or polluted dust aerosol subtypes based on nine years of CALIPSO observations (01/2007-12/2015) and for five zones of 10° latitudinal interval, between 5° and 55° N.".
Page 12.11: The misleading sentence is rephrased according to the reviewer's recommendation from "In general, to the north of Himalayas (Fig. 7e-h), a structure of three different height ranges is evident." to: "In general, to the north of Himalayas, low values of particle depolarization ratio are observed close to the surface, while particle depolarization ratio increases with increasing height (Fig. 7e-h).".

Page 13.1: Rephrased to: "Over Thar Desert the average particle depolarization ratio of cases classified as dust or polluted dust by the CALIPSO classification algorithm yield average depolarization values greater than 25% throughout the year".
Page 13.2: Height in Fig. 4 are defined above ground level while at Fig. 5, 6 and 7 characteristic are above sea level.
Page 13.3: Comma added.
Page 13.4: The sentence is deleted after cross-checking.
Page 13.5: The entire manuscript is homogenised accordingly.

Page 14.1: Over the manuscript frequently the authors have discussed the horizontal and vertical distribution of AOD and dust aerosol respectively. Both MODIS Aqua and CALIPSO CALIOP are utilized. Both sensors utilize different algorithms for cloud screening for cloud fraction and extensive cloudiness prevent retrievals over specific domains (Bay of Bengal and monsoon period). These figures, although not extensively discusses, are in the manuscript for completeness reason, for a reviewer to have a full overview of the datasets utilized.
Page 14.2: According to the reviewer's recommendation the sentence is rephrased from "Strong statistical increase is observed by MODIS over the Arabian Sea (0.01 yr^{-1}), while not statistical significant positive AOD550nm trends are present over the Bay of Bengal (0.002 yr^{-1})." to "MODIS shows not statistical significant AOD increasing trends of the order of (0.002 yr^{-1}) over the Bay of Bengal and strong positive statistical significant trends over the Bay of Arabian Sea (0.01 yr^{-1}). The strongly increasing AOD trend over the Arabian Sea though is not corroborated by CALIOP observations.".
Page 14.3: The abbreviation is removed according to the reviewer's suggestion.

Page 15.1: Indeed, the reviewer is right. Based on CALIOP both the horizontal and vertical distribution of aerosol can be studied.
Page 15.2: According to the reviewer's recommendation the abbreviations are explained one last time in the beginning of the "Summary and Conclusions" section. To be more specific the following phrase is modified: "Our analysis shows similar

patterns in the horizontal distribution of Aerosol Optical Depth (AOD), Dust Aerosol Optical Depth (D_AOD) and Non-Dust Aerosol Optical Depth (Non-Dust AOD) between all four seasons ...".

Page 15.3: The authors mean, the range of the observations, how high/low the observed values are.

Page 15.4: Corrected.

Page 15.5: According to the reviewer's recommendation the sentence is rephrased: "The CoM, TH and the mean extinction coefficient profiles are implemented in order to provide the vertical dust aerosol distribution, and together with the horizontal distribution of AOD and D_AOD to provide in the end the three-dimensional structure of dust aerosol over South and East Asia and the atmospheric dust aerosol transport pathways.".

Page 15.6: "The Summary and Conclusions" Section is adapted according to the reviewer's suggestion (major comment).

Page 15.7: The sentence is rephrased. Actually the entire "Summary and Conclusions" Section is modified. The Angstrom Exponent and the spectral dependence of AOD is crucial since it can be used as a fingertip for identifying coarse aerosol types and different aerosol cases (e.g. dust or non-dust cases)

Page 15.8: Comma added.

Page 26.1: "Under" is deleted.

Page 26.2: Capital "T" is used according to the reviewer's correction.

Page 26.3: Clarified. "Climatological" is added.

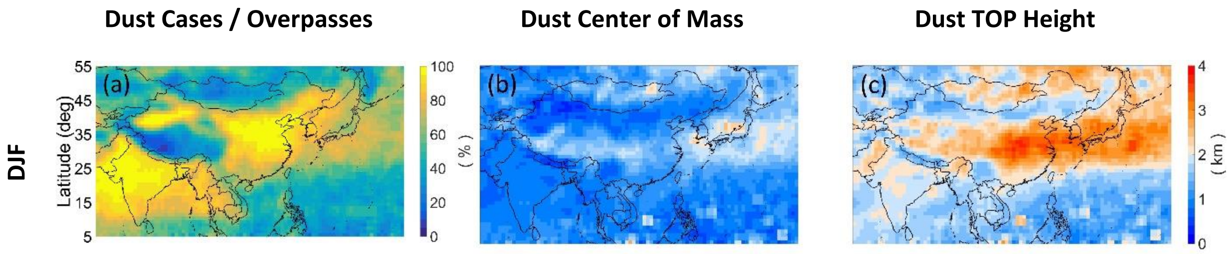
Page 26.4: Indeed the two figures it is better to be plotted together, the authors totally agree with the reviewer's recommendation.

Page 26.5: Corrected. Word "Geographical" is deleted from the caption of figures 5, 6 and 7.

Page 27.1: Both the scale and the colormap are modified, according to the suggestion by the reviewer. Please see the figures below, before and after the adaptation of the figures.

Page 27.2: Both the scale and the colormap are modified, according to the suggestion by the reviewer. Please see the figures below, before and after the adaptation of the figures. In addition the phrase "please note the different height scale" is added to the manuscript.

<u>Before</u>



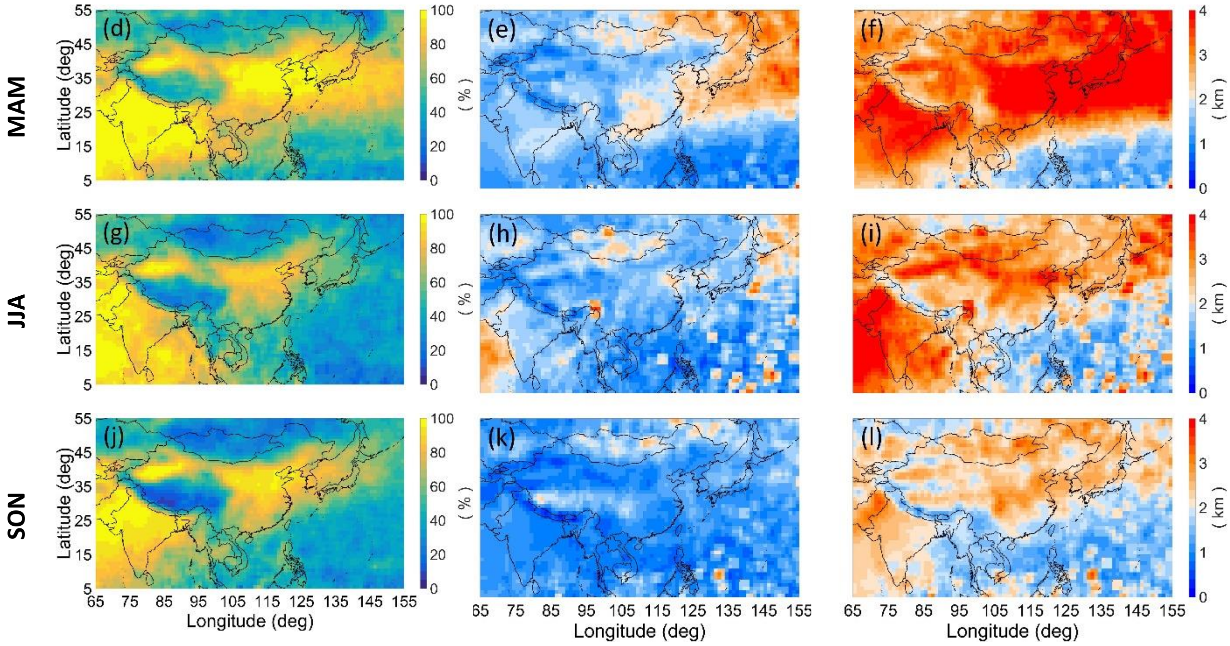


Fig. 4: Spatial distribution of dust occurrence [%], climatological pure-dust CoM (Center of Mass) and dust TH (Top Height) in km a.g.l., for each season over the domain between 65°-155° E and 5°-55° N and for the period 01/2007-12/2015.

<u>After</u>

Dust Cases / Overpasses **Dust Center of Mass** **Dust Top Height**

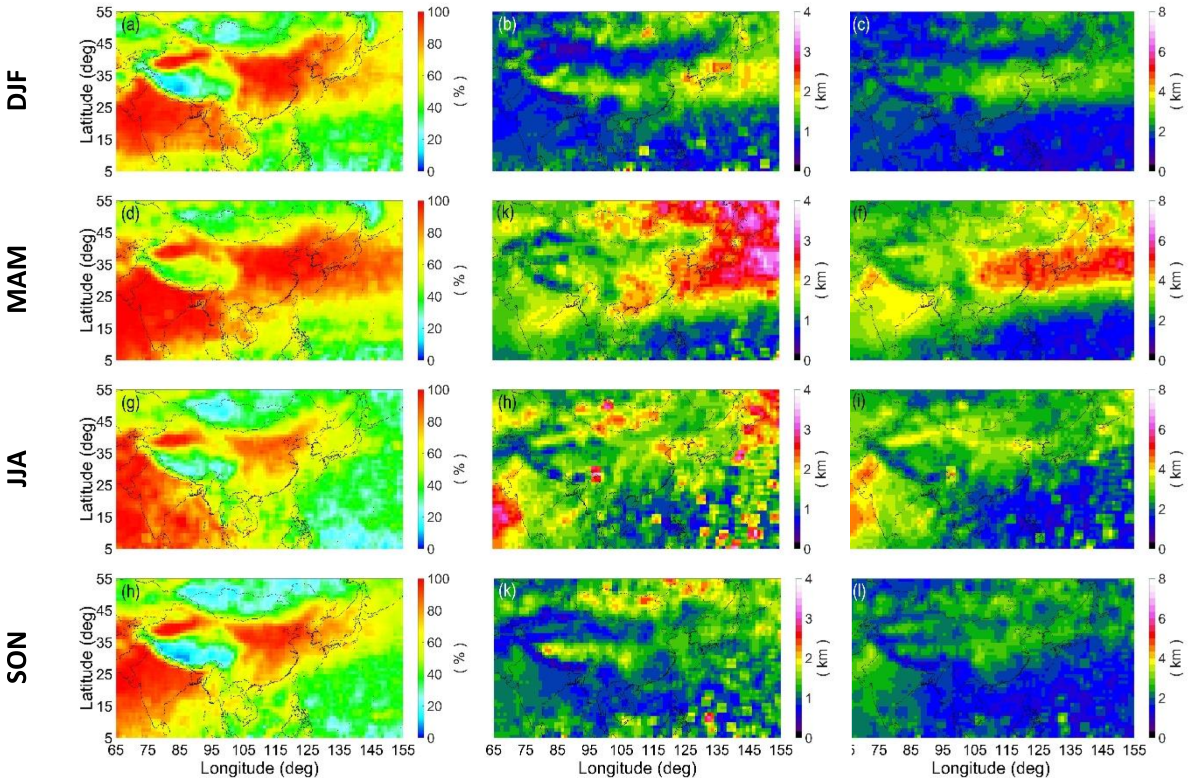


Fig. 4: Spatial distribution of dust occurrence [%], climatological pure-dust CoM (Center of Mass) and dust TH (Top Height) in km a.g.l., for each season over the domain between 65°-155° E and 5°-55° N and for the period 01/2007-12/2015.

Page 30.1: Since CALIPSO CALIOP classifies layers as dust or polluted dust over these domains, even if the frequency is low - as indicated by the question of the reviewer, it makes sense to decouple those few cases to the pure-dust and non-dust components of the detected aerosol mixtures. The need is supported also by the evidence that dust sources are not only natural but anthropogenic activity may also lead to dust particles in the atmosphere, over domains where no natural dust is supposed to be observed through intercontinental transport. Chen, S., Huang, J., Jiang, N., Zang, Z., Guan, X., Ma, X., Jia, Z., Zhang, X., Zhang, Y., Huang, K., Xu, X., Zhang, G., Li, J., Yang, R., and Liao, S.: Estimations of anthropogenic dust emissions at global scale from 2007 to 2010, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2017-890, in review, 2017.
Page 30.2: Suggestion is implemented – comment 27.1.
Page 30.3: The scale of figures are adapted according to the recommendation of the reviewer in order to include both higher values (comments 27.1, 27.2, 30.3)

Page 31.1: The authors are of the opinion that any redundant information added on the figures 5, 6 and 7 would make it harder to read features on them. Thus the authors have not included marks indicating the desert regions on the figures, since a reader can take the information of the regions of interest and the locations of the deserts from Figure 1.
Page 32.2: According to the reviewer’s recommendation, the caption of the colormap is changed to: “Dust Extinction Coefficient”.