Responses to Comments from Referee #1

1. General comments:

Chen et al. present in their study "Potential impact of aerosols on convective clouds revealed by Himawari-8 observations over different terrain types in eastern China" the impact of terrain height, meteorological parameters, and diurnal cycle on the aerosol-cloud interaction. The authors used two seasons from May-September 2016-2017 of observations from the geostationary satellite Himawari to retrieve the cloud mask, particulate matter from measurement station to retrieve the pollution concentration, MERRA-2 reanalysis to retrieve lower-tropospheric stability, vertical velocity, potential temperature, relative humidity, and specific humidity at different levels in accordance with the terrain height. The study describes an innovative convective cloud mask that the authors developed and they collocate spatially and temporally with pollution and meteorological information. They infer an exhaustive list of interaction of clouds with their environment with some important features on the aerosol-cloud interaction, convective clouds occur more likely under unstable environment with some caveat comparing the morning and the afternoon and they compared between clean and polluted environment for example. I specifically appreciated that the authors provide a physical explanation for the different observations they acknowledged that they are using observations and further work is needed to support the interpretations and conclusion. The overall presentation is well structured and clear and the Figure are explanatory and provide argument for the text. The scientific method and assumptions seem valid and they are clearly outlined. I have some concerns regarding the conclusion of the article and the strong statement that the article study the impact of aerosol on convective clouds but I am not sure about that, as the data are not compared with clear sky situation, I developed what I mean in the next section. I have also some concern about the cloud mask validation, but I think it just a lake of details from the current version. Finally, working with a large amount of data, statistical tests are missing to quantify the effect observed. Otherwise, the topic and the results fit totally within the scope of ACP and I strongly recommend the publication in the ACP after some modifications.

We thank the reviewers for their thoughtful and excellent comments and suggestions. We have tried as much as possible to address all concerns and have revised the manuscript accordingly. The reviewers' comments are written in normal font, and our point-to-point responses to the reviewers' comments are in bold.

2. Main comments

1. The study compares different regimes, handling a large dataset and the conclusion often belongs to observation from the Figures. Quantification through

statistical tests are often missing to support the description and the conclusions.
I put some examples here:

- l. 394: The authors mention "non negligible contributor. . . ", the changes in ω do not seem statistically significant, did the authors try to perform a statistical test?

Response: By considering main comment 3), we have changed Figure 5 into the CC OF anomaly, and carried out a χ^2-test to see if the differences are significant. More details can be found in the response to main comment 3).

- The key of the study is explained in lines 598-602, with the explanation of de-correlation between meteorological parameters and the PM2.5 concentration. I do not know if we can say that q (for example) is uncorrelated with PM2.5. Did the authors try to quantify the potential correlation between the different parameters?

Response: By examining all potential influences, we found that $PM_{2.5}$ concentrations can have correlations with meteorological factors. So, we tried to plot the 2-d CCF distribution under different meteorological parameters and different $PM_{2.5}$ concentrations. We have divided the $PM_{2.5}$ concentration into 10 equally sampled bins to reduce the influence of sampling bias for the CCF distribution. Thus, although we cannot exclude the influence of meteorological factors to $PM_{2.5}$, the relationship between aerosol and convective cloud is still robust.

Additionally, to avoid the impact of hydration on aerosol, the PM2.5 measurements we used are dried particle masses; we have added this statement in section 2.2 and 4.4.

In section 2.2: *"On the other hand, particulate matter can be measured from the surface or aircraft under all-sky conditions and can provide dried particle masses which can minimize the influence of moisture on it."*

In section 4.4: *"As PM2.5 measurements are dried particle masses, which can minimize the influence of ambient moisture, these patterns are more likely related to the strengthening of the aerosol microphysical effect, which might overtake the suppression from the aerosol radiative effect in higher aerosol loading conditions in these regions."*

We also added a statement in section 5 to further explain the relationship of meteorological factors and aerosol effects on convective clouds:

"A possible alternative explanation is that aerosols and CCF are associated because they are both affected simultaneously by the same meteorological factors. However, CCF had generally similar relationships with aerosol mass concentrations for all meteorological stratifications that were examined. This observation renders the alternative meteorological explanation less likely."

- l. 537: The authors mention "especially before 14:00 LT", I do not see a difference at all between polluted and clean after 14:00 from Figure 10, I think the term "especially" should be change for "only". For this entire section, I doubt that the results are statistically significant, did the authors try to perform a test?

Response: We have removed the word "especially" in this sentence, and we have also replotted Figure 9 and 10 to make the mean value more visible and added dots on the points that have differences exceeding the 95% significance level according to a student's t test.

• Line 618: CCF peaks decrease under stronger updraft, I am not sure to understand what it is meant here, I think quantification would help.

Response: Thanks for pointing out the problem, here we only mean that the turning point is moving to smaller values, not the CCFs, we have fixed this sentence as follows:

"However, the turning values of CCF generally decrease with increasing updraft conditions as well"

• I am not convinced by Figure 11, the differences between the graphs are not high. Did the authors try to quantify the difference with a statistical test? Moreover, the highest terrain is not the one with the minimum CC fraction for PM2.5 greater than 30μg/m^3. I am curious on how does it fit on the author's explanation? Is it the different between plateaus and hill?

Response: Per your suggestion, we did significant tests for all the points in the figure. Within each PM2.5 bin, Student's t-tests were carried out for each pair of CC fractions for the four terrain height bins. For all the distributions, the null hypotheses are rejected, which means that each pair of distributions is significantly different (at 95% significance level). The p-values of the t-test for the ten $PM_{2.5}$ bins are listed as follows:

Tabel R1. p-values of the t-test for the ten $PM_{2.5}$ bins to each pair of the terrain-height bins. Note that differences that passes the 95% significance level are in bold.

Terrain Heights (m)		**PM2.5 bins**									
Group1	Group2	1	2	3	4	5	6	7	8	9	10
0-500	500-1000	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
0-500	1000-1500	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
0-500	1500-2000	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
500-1000	1000-1500	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
500-1000	1500-2000	0.10	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**
1000-1500	1500-2000	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Meanwhile, each of the CCF curves is calculated within each sub-region, which means that the sum of all the numbers of each CCF curve is 100%. So, we rewrote the sentence as follows:

"We calculate the CCF using the number of convective clouds within each of 10 equally sampled PM2.5 bins divided by the total convective cloud amount over each sub-region. Each pair of CCFs in the four sub-regions is significantly different at 95% significance level according to the Student's t-test."

Over higher terrains, aerosol concentrations are relatively lower, and the effect of topography might play a more important role. Surface heating is stronger at the higher elevation, which may dominate the trend of decreasing CCF by more convective cloud formation, so that the inhibition of convective cloud by aerosol radiative effect is weaker. Thus, the CCF at $PM_{2.5}$ greater than 30 μg/m^3 over 1500-2000m region could be larger than CCF over 1000-1500m region.

We have also added this explanation in the context:

"Over higher terrains (TH>1000m), aerosol concentrations are relatively low, and the

effect of topography might play a more important role. Surface heating is relatively stronger at the high mountains(TH>1500m), which may dominate the trend of decreasing CCF after the turning zone, so that the inhibition of convective cloud by aerosol radiative effect is weaker, and the CCF is higher than the plateau regions (1000<TH≤1500m) after the turning zone."

2. I need some clarification about the cloud mask.

- l.295-l.307: Some of the thresholds from which the cloud mask is based on correspond sometime to mature and small convective clouds, is it a problem? Did the authors try to change the different thresholds? If yes, how does it affect the results?

Response: One of the objectives of this study is to find out the relationship between aerosols and convective clouds, as we have set a threshold to select convective cloud smaller than 10000 pixels, mostly small local-scale convective cloud systems are included. We combined the small and mature convective cloud systems only to see whether aerosol can affect the occurrence of convective clouds, but did not draw much attention to the aerosol effect on different stages of development or types of convective clouds. We assume that aerosol loading can affect the triggering and development of convective clouds, so that the occurrence frequencies are relatively different under polluted and clean conditions regardless of their stage of development. We have also classified the identified convective clouds based on their cloud top temperatures being above or below 0°C as shallow or deep convection, and found that their responses to aerosol are similar (Figure R1 and R2), with more convective clouds found before noon time and less in the afternoon under polluted conditions in general. These results further indicate that the occurrence of small local-scale convective clouds can be influenced by aerosol loading regardless of the development stage, although the effect may alter the development of convective clouds. So, the results we used in this study have just combined together the shallow and deep convective clouds.

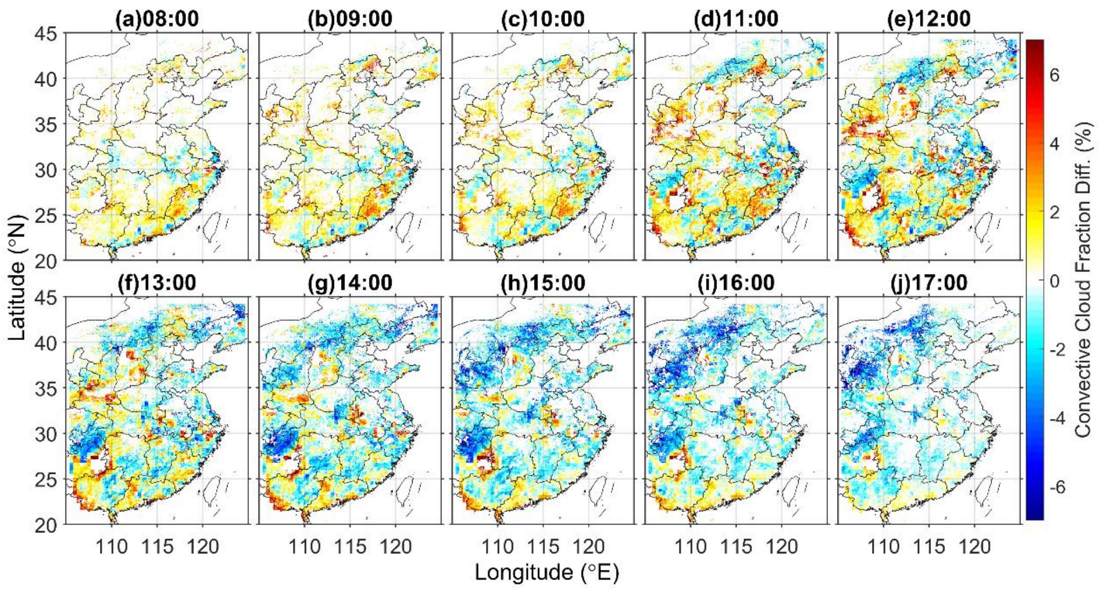

Figure R1. Diurnal changes of shallow convective cloud (mean cloud top temperature > 0°C) fraction difference between polluted and clean environments (Polluted-Clean)

during May-September in 2016-2017. Time marked above each figure is the local time. Grid points are plotted only if they exceed the 95% significance level ($p < 0.05$) according to the Pearson's $\chi 2$ test.

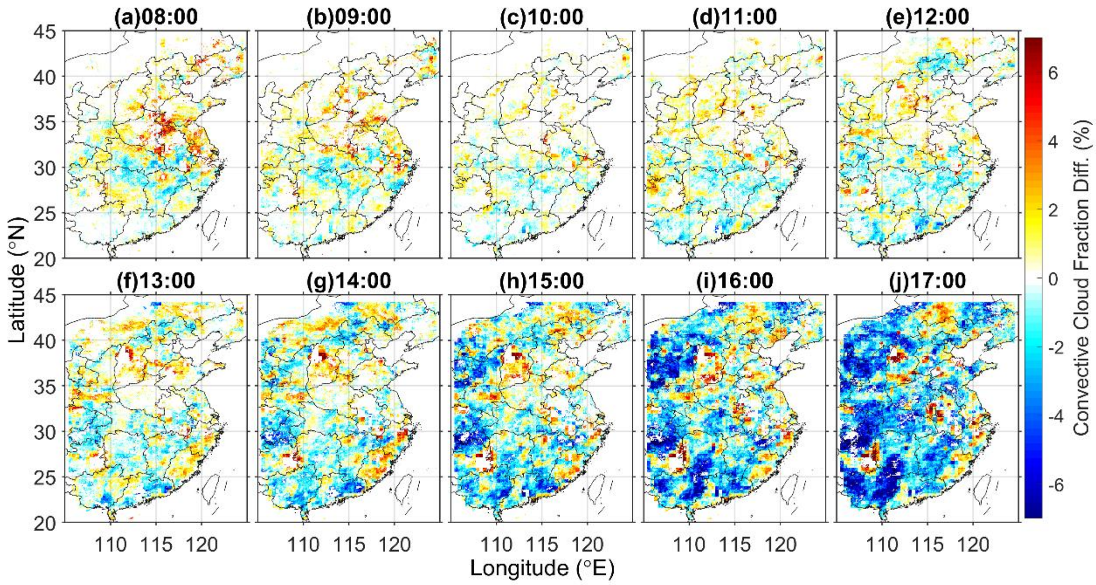

Figure R2. Same as Figure R1, but for deep convective clouds (mean cloud top temperature < 0°C)

However, there are differences in detail between the shallow and deep convection. The reason for these differences is likely to lie in the different effects of aerosol at different stages of convective cloud development. So, we are planning to explore the responses of convective clouds at different stages of development to aerosol loading in future work, so as to provide more details about the changes in convective clouds under polluted conditions.

As the thresholds we use in this study are mainly from VIS channel, it is certain that the areas of identified cloud clusters can vary with the choice of threshold. But we think the main difference may lie in the ratio of deep to shallow cloud clusters, and as these filters become stricter, most of the mature convective cloud anvil and some very shallow convection will be excluded. But, as we previously found, the response of shallow and deep convective cloud to aerosol loading could be similar. Therefore, the changes in the thresholds may not have very large impact on the results.

- The validation of the cloud mask has been performed on a specific day. The method works well on a day with a lot of convective clouds, but how does it perform if there are less convective clouds? When the authors compare with ISCCP regimes, does it refer to the cloud optical depth/cloud top pressure diagram? Can the authors describe how the ISCCP define convective clouds? If I understand correctly, at 8:00 there is an accuracy of 20% of the author’s cloud mask algorithm to detect convective clouds, is it correct? I consider the author’s method more robust than the COT-CTP diagram. Can the authors comment on that? The results from this part are interesting but I am not convinced that it serves as a validation of their algorithm.

Response: Figure 3 is only taken as an example of identified convective clouds to show the performance of the TCT-CID method, but our validation employs much more data (about 20455 scenes from May to September in 2016 and 2017) in Figure S2. To show the performance of the cloud identification method more clearly, we have replotted Figure 3 in smaller area, and added another case comparison between MODIS cloud mask and our identification result. We choose a scene with sparse convective cloud in the mountain area in northern China and nearly no other types of clouds are included. We have rephrased the sentences to make this point clearer as follows:

"Figure 3 presents two examples of convective clouds identified in the hilly regions in southern China at 13:40 LT on July 30th, 2016 and in the mountain regions in northern China at 14:20 LT on June 22nd, 2016. To get a general idea of the performance of the TCT-CID method, we compare the identified convective cloud masks against the MODIS/Aqua MYD35 cloud masks. As the MODIS product does not classify clouds into different types, a scene which contains a vast convective cloud field and a scene with sparse convective clouds are chosen."

In Figure S2, we plot the ratio of ISCCP cloud types corresponding to the identified convective cloud, which means that the frequencies of different cloud types corresponding to the identified convective cloud masks are calculated as the percentage of the pixel number of convective cloud mask which matches each ISCCP cloud type to all the cloud mask pixels. For example, at 08:00, over 20% of the identified convective cloud mask matches the level 2 DCC cloud type. To make this point clearer, we have rewritten this paragraph in section 3.2 as follows:

"This product provides the cloud type information using the ISCCP cloud classification criteria, which defines cloud type using specific combinations of cloud top pressure (CTP) and cloud optical thickness (COT) (Rossow and Schiffer, 1991). A COT-CTP diagram is created to differentiate cloud types with different radiative feedbacks. This method provides to some degree an accurate identification and classification of various cloud types. In this study, we compared the identified convective cloud masks with the L2CLP cloud type product. The frequencies of different cloud types corresponding to the identified convective cloud masks are calculated as the percentage of the convective cloud mask pixel count that matches each ISCCP cloud type to all the cloud mask pixels (Figure S2)."

Reference:

Rossow, W. B., and Schiffer, R. A.: ISCCP Cloud Data Products, 10.1175/1520-0477(1991)0722.0.CO;2, 1991.

We provide an example of a case comparison between our identification method and the L2CLP cloud type product. The red part in Figure R3b is the identified convective cloud by our method, the cyan part is the L2 cloud type product (Only deep convective cloud, cumulus and stratocumulus are included), the blue parts are the overlaps of the two products. We can find a generally good agreement with the two products. Our method shows better performance in identifying the deep convective clouds, the areas of the deep convections are larger than the L2 product, but the capability of identifying shallow

convective cloud is limited. We also added a discussion in section 3.2 to point this out:

"The method is designed to find sharp edges and bright clusters in VIS images firstly, but as some of the high clouds may also fit these conditions, which are not the subject of this study, we added a split-window filter to exclude this kind of clouds. However, the addition of this filter will also exclude the anvils of some mature convective clouds and some of the shallow clouds, so the cloud area identified by our method is smaller than the cloudy area found by the MODIS cloud mask and the capability of shallow convection identification is limited. Nevertheless, the majority of convective clouds are well captured by our method."

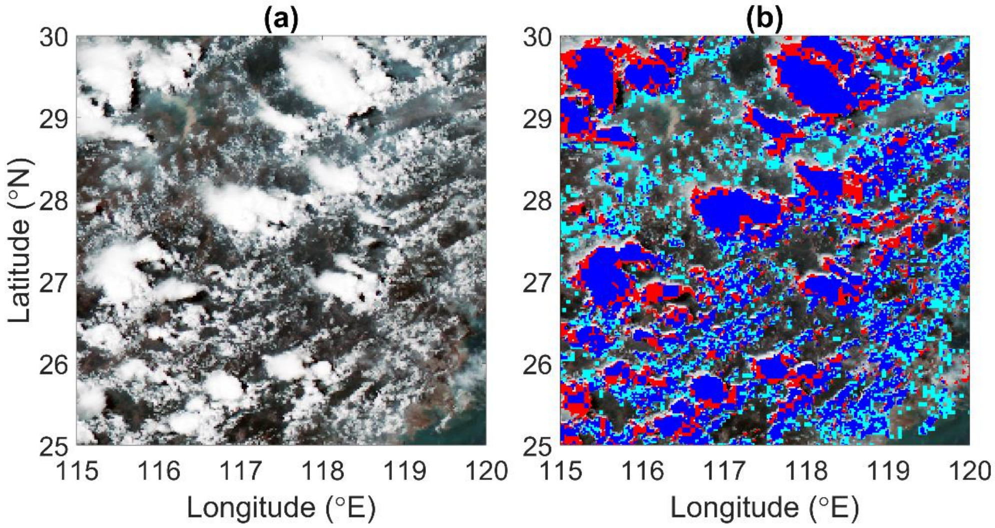

Figure R2. Comparison between convective cloud mask identified by our method and the Himawari-8 level 2 cloud type product. (a) True color image, (b) comparison between the two products, red parts are convective cloud mask from our method, cyan are from L2 product including DCC, Cu and Sc, blue parts are the overlaps.

- On Figure 3, there are some clouds that are not detected by the algorithm but they are by MODIS and they could be convective (on the eastern part of the figure), can the authors have an explanation for that and can they comment it? In the article, the authors mention the opposite and refer to other cloudy pixels. I think it mainly refer to cloud edges, can the authors comment on that?

Response: By rechecking the data, we amended the figure of MODIS cloud mask in Figure 3. As we have screened the cirrus with the split-window method to isolate only convective clouds, the cloud area identified by our method is smaller than the cloudy area found by the MODIS cloud mask.

3. I am confused about the aim and the conclusions of the study. On line 642 "However testing whether the results are due mainly to aerosol effects is only a first step", the authors answered many questions in the manuscript but I do not see how we can affirm that aerosols are the main contributor to convective cloud occurrence. Further analysis would be needed to study the aerosol-cloud interaction, comparing with non-cloudy pixel occurrence constrained for meteorological parameters for example. I do not know if the meteorological conditions discussed in the text favored the convective cloud formation or "simply" the cloud formation. It is acknowledged in the text but it can be misleading in

many parts of the manuscript. How are the meteorological parameter variations with clear sky occurrence (for example Figure 5)? Is it really the conditions which favored the convective cloud occurrence or is it the meteorological conditions difference between the areas and another parameter which favor or inhibit the cloud formation? Do the authors take that into account?

Response: We appreciate this comment. We would admit that there are limitations in reaching definite conclusions only based on observational data in the current study. Thus, we have rephrased many of the sentences in sections 4.2-4.4 and the summary to make it clear that we cannot find aerosol "as the reason" of the phenomena but is likely "to be related" to the phenomena. And we have changed the sentence you mentioned here to:

"However, identifying the apparent correlations between convective cloud and aerosol loading is only a first step, supporting the hypothesized mechanisms by which aerosol affects convective cloud occurrence. The mechanism by which the aerosol and meteorology interact is another important question, that is beyond the scope of the current study."

To compare the convective cloudy pixels with the non-cloudy pixels, we have replotted Figure 5. Instead of the using the convective cloud occurrence frequency (CC OF), we use the anomaly of CC OF. This could have made the difference in meteorological conditions between the presence of convective cloud and the all-sky conditions clearer. And we also rewrote section 4.1 to describe the new Figure 5. Generally, we can find from Figure 5 that convective clouds prefer stronger CAPE, surface heating, updraft and higher moisture, and the difference in mean values between the convective-cloud condition and the all-sky condition is larger over higher terrain regions.

There are differences in the meteorological conditions between different areas, especially for lower and higher terrains, and differences are also obvious when convective cloud occur. Thus, we generate Figure 13 and 14 to discuss the potential influences of meteorological parameters to the aerosol-CCF relationships.

4. Cloud interactions with aerosols and cloud processes are different over land or over ocean. In the study the authors merged over open ocean and over land. Did the authors try to remove the ocean in their analysis?

Response: In this study, the relationship between aerosol and convective cloud is mainly discussed over land, as the PM2.5 observations are available only over the continent. The ocean area is removed from the study. To make this point clear, we have added a statement in section 2.1 as follows:

"As PM2.5 data is only available over mainland China in this area, the aerosol-convective-cloud relationship is only discussed over the continent in this study."

Additionally, we have also removed the data over ocean area in Fig 7.

5. Specific comments

1. Figure color bars: The rainbow color bar is not suited for colorblind people; I suggest to change it.

Response: Thanks for the suggestion, it is great to consider the readers, we have changed

the rainbow color in Figure 4, 8, 13 and 14 with a simpler color scale.

2. l. 37: I suggest to change to "convective cloud fraction increaseS then decreaseS"
Response: Changed.

3. l. 44: I suggest to change to "aerosolS decrease. . . "
Response: Changed.

4. l. 50: I suggest to change to "Convective cloudS are. . . "
Response: Changed.

5. l. 57: A space is missing between "climate" and (Zhao et. . .)
Response: Added.

6. l. 60: I suggest to change to "light-absorbing aerosolS"
Response: Changed.

7. l. 103: "In recent years. . . ", then the authors refer to Lynn et al. (2007), is it still considered as "recent years"
Response: We have removed the statement "In recent years" in this paragraph.

8. l. 105: "WRF" is not spelled out I think
Response: We have added the full name of WRF as "Weather Research and Forecasting (WRF) Model".

9. l. 113: "Only few studies. . . ", can the authors cite the few studies they are referring to.
Response: We have rephrased the sentence and added references here:

"Only a few studies include long-term observational data to analyze the relationships between aerosol and orographic precipitation statistically (e.g. Rosenfeld, 2007; Guo et al., 2014)"

References:

Rosenfeld, D., Jin Dai, Xing Yu, Zhanyu Yao, Xiaohong Xu, Xing Yang, Chuanli Du (2007), Inverse Relations Between Amounts of Air Pollution and Orographic Precipitation, Science, 315, 1396-1398, doi:10.1126/science.1137949.

Guo, J., M. Deng, J. Fan, Z. Li, Q. Chen, P. Zhai, Z. Dai, and X. Li (2014), Precipitation and air pollution at mountain and plain stations in northern China: Insights gained from observations and modeling, 119(8), 4793-4807, doi:https://doi.org/10.1002/2013JD021161.

10. section 2.1: It is not clear here if they consider data over ocean or not.
Response: Only convective cloud over land is considered in this study, to make it clearer, we have added a statement in this section.

"As $PM_{2.5}$ observations are available only over land in this area, the aerosol-convective-

cloud relationship is only discussed over land in this study."

11. l. 160: Can the authors plot the region of interest in Figure 1, it is not clear which region is covered or not.

Response: The whole region in Figure 1 is the region of interest in this study, we have rephrased these sentences in section 2.1 as follows:

"In order to investigate the joint impact of aerosol pollution and topography on convective cloud fraction and diurnal variation, we chose the area within longitudes 105°E to 125°E, and latitudes 20°N to 45°N as the region of interest (ROI) for this study. We show the terrain distribution and the mean concentration of particles with aerodynamic diameters smaller than 2.5 μm ($PM_{2.5}$) during May-September in 2016-2017 over the ROI in eastern China in Figure 1. Generally, terrain height (TH) tends to increase from east to west in this region, and $PM_{2.5}$ mass concentration is generally higher over the plains and lower over mountain ranges and plateaus."

12. l. 188: Is PM_1 used in the study? The article mainly refer to $PM_{2.5}$ only.

Response: PM_1 is not used in this study; here we mean that particulate matter with small diameter, such as PM_1 or $PM_{2.5}$, may be taken as a proxy of CCN. To make the statement clearer, we have rephrased this sentence as follows:

"Particle size up to 10 μm may be much larger than the typical scale of CCN, so particulate matter up to 1 μm (PM_1) or 2.5 μm ($PM_{2.5}$) in diameter is more appropriate to serve as a CCN proxy. Due to the limited availability of PM_1 measurements in eastern China, we chose PM2.5 as an indicator of different CCN levels in the environment for this study."

13. l. 253: Is q really at the surface or at 2m above surface?

Response: Specific humidity at 2 m above the surface is used to represent the near-surface moisture. We have changed the "surface specific humidity" to "specific humidity at 2m".

14. l. 271: What is the matrix size?

Response: In this study, the matrix size is the size of the image in the region of interest; there are 1251×1001 pixels in the region. To make it clear, we have added *"(in this study, m = 1251, and n = 1001, as both the zonal and meridional spatial resolutions are 0.02° in the ROI)"* in the text.

15. l. 300: "With mean contrast>3.5", where does the value of 3.5 comes from?

Response: The clustering method provides us five clusters, as the identification tends to be unstable when the cluster number larger than 5. And we exclude the two clusters with lowest mean contrast, the second smallest mean value is about 3.5. We rephrased the sentence as follows:

"Five clusters are classified, and the mean contrast values are calculated. Those clusters with relatively higher "contrast" (with mean contrast>3.5, which is the second smallest among all the cluster mean contrast values) are considered either small convective clouds or the edges of mature convective clouds."

16. l.312: I suggest to change to "isolating convective cloudS"
Response: Changed.

17. Fig. S1: Is this graph only for July 30th 2016 or for the two seasons considered later?
Response: This figure is for the two seasons (from May to September in both 2016 and 2017). We have added the time period in the figure caption as follows:

"Figure S1. Frequencies of cloud types corresponding to the identified convective cloud with TCT-CID method in the warm seasons (May to September) of 2016 and 2017.…"

18. Fig. 4: It is difficult to distinguish the gray line, the author should highlight it differently.
Response: As the gray line is hard to see in this figure, we have removed the province boundaries and plot the gray line in black.

19. l. 398: "most common", do the authors mean "higher".
Response: We have changed the word into "higher".

20. Fig. 4: Are the sub-figures snapshot of the specific time indicated or is it integrated over two hours?
Response: The subfigures are calculated by accumulating all the 6 observations (every 10min) within the hour (e.g., from 08:00-08:50) during the two warm seasons of 2016 and 2017. To make this point clearer, we have added a statement in section 4.1.

"Figure 4 shows the frequency of convective clouds occurring between 08:00 and 17:00 LT, calculated by dividing the number of convective clouds observed in six observations per hour (one every 10 minutes, e.g., 08:00-08:50) by the accumulation between 08:00 and 17:00."

21. l. 422-424: Considering the potentially high spatial variability of aerosol with the different terrain heights, how good is the "nearest-pixel" assumption?
Response: By considering this comment, we have made a comparison between the station-measured and the interpolated $PM_{2.5}$ concentrations in the following figure. The scattered dots are the $PM_{2.5}$ measurements at each site, and the gray dots are the interpolated $PM_{2.5}$ at each grid box. We can find very good agreement between these two datasets, which indicates that the assumption did not bring large uncertainties to the spatial distribution of $PM_{2.5}$.

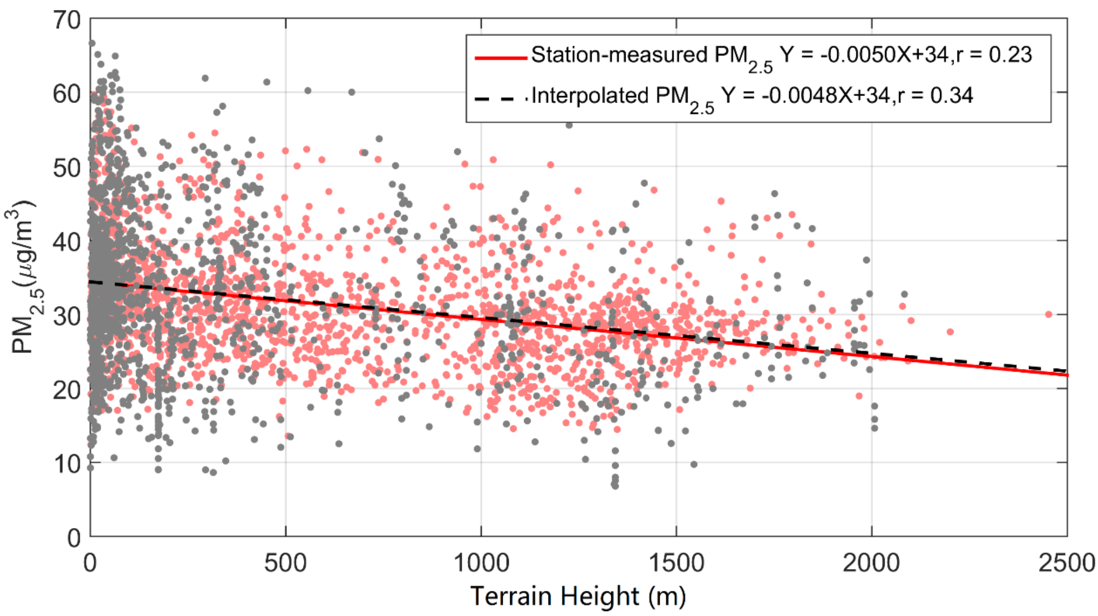

Figure R3. Station-measured $PM_{2.5}$ (red dots) and the interpolated $PM_{2.5}$ (gray dots). The linear regression lines are shown as solid red line for the station-measured $PM_{2.5}$ and the dashed black line for the interpolated $PM_{2.5}$, respectively.

22. Fig. 6: It is difficult to distinguish between the red and magenta lines, I suggest to find other colors.

Response: Per your suggestion, we have changed it into a solid red line to make it clearer for readers to see.

23. l. 535: "We can see from Figure 11. . . ", I think the authors want to refer to Figure 10.

Response: Thanks for pointing out the mistake, the mistake has been corrected.

24. l. 706: I suggest to change "convection by the enhancing" to "convection by enhancing".

Response: Changed.

25. l. 708: I suggest to change "development of convective cloud" to "development of convective cloudS"

Response: Changed.

26. Figure 7: There are red spots that the authors highlight with the presence of cities. What about the other red spots, is there any reason?

Response: We have discussed other red spots in the text, to make it clearer, we have rephrased the sentence as follows:

"There are also red dots located near several mountain areas, as complex topography may also be related to such a phenomenon. Furthermore, different topography may also lead to different convective cloud response to aerosol loading."

27. Figure 8: The caption mentions "red solid lines" but the lines seem dashed.

Response: We have replotted Figure 8 to change the color as concerned in comment 1), and increase the linewidth of the red lines.

28. references: Many doi are missing
Response: We have added dois for the references as much as we can.

29. There are "Houze Jr, R. Q.: Cloud dynamics, Academic press" twice, for 1993 and 2014. Can the authors use only one edition ? I would suggest the most recent one.
Response: We have removed the 1993 edition.