Using three 6-month simulations with the WRF-Chem model, this paper examines the impact of anthropogenic and biomass burning aerosols on radiation fluxes, cloud, precipitation and atmospheric circulation during the Asian Summer Monsoon in 2008.
However, the reviewer has some major concerns about the experiment designs and results (see below). Meaningful and helpful results are also lacking in this study.
➔Response: Thanks for all the comments. We have taken into account the reviewers' comments and revised the experiment design and results. More detailed responses are presented below.

Major comments:
1. This study gives just one simulation for each case in 2008. The statistical significance of the results can't be tested. So we cannot be able to tell the differences are real signals induced by aerosols or just noise associated with internal variability of model or interannual variability of climate. Then the question is how meaningful of the conclusions of this study if they vary year by year or case by case. Therefore, the reviewer strongly recommends that the authors should extend the current simulations with a number of ensembles to consider the internal variability of model and interannual variability of climate. The difference between two experiments should be accompanied by a test of the significance.
➔Response: We have carefully considered the comment and more ensemble simulations are included in the revision. Since this is just a case study, more simulations for different years and different cases would be beyond the scope of this work. As aerosol impacts on climate still remain large uncertainty, more work is needed to further understand this topic.

2. In terms of the choice of year 2008, there was emission control around Beijing due to the Olympics. I am not sure year 2008 is a good choice to represent the aerosol impacts in regional climate over Asia, especially that the emission sources in the WRF-Chem simulations are from INTEX-B (based on 2006) and RETRO (climatological) datasets.
➔Response: We agree with the reviewer that the emission control around Beijing due to the Olympics could have some impact on the emission sources. However, some studies (i.e. Gao et al., 2011) found that the local emission control does not affect the regional scale emissions much as the control was more local scale. Also, our study domain and focused regions are away from Beijing. The small change in Beijing emissions would not have big impacts on our results. Besides, the control period was for a short period. There were no big differences in emissions in June or July. We also acknowledged that the emissions data used in this study have some limitations in the paper.

Gao, Y., Liu, X., Zhao, C., and Zhang, M.: Emission controls versus meteorological conditions in determining aerosol concentrations in Beijing during the 2008 Olympic Games, Atmos. Chem. Phys., 11, 12437-12451, doi:10.5194/acp-11-12437-2011, 2011.

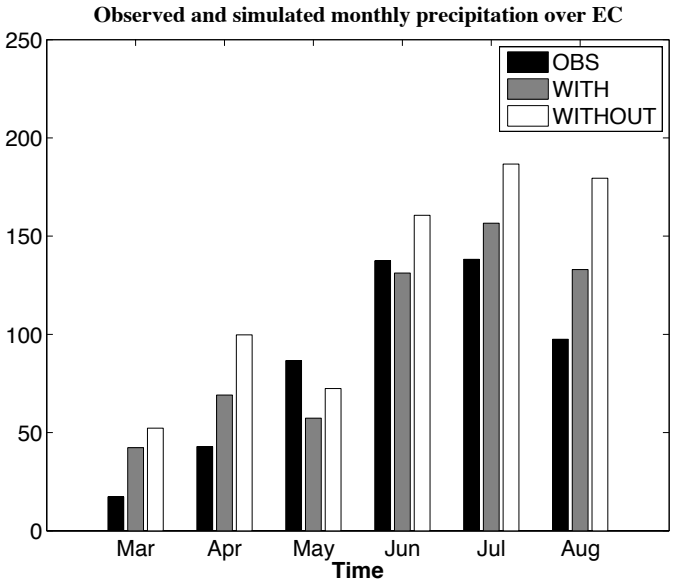
3. Figure 2 and Figure 3: The model simulated AOD are significantly underestimated comparing to the observations, especially over India in Figure 2 and over AERONET sites in Figure3. Does the significant underestimation of AOD have any influence on the simulated climatic effect of aerosols in these regions?
➔Response: Yes, the underestimation of AOD could have some influence on the simulated results. We have added some discussion on this.

4. Please quantify the aerosol-induced changes of clouds and precipitation.
➔Response: Some quantitative results regarding clouds and precipitation are added in the revision.

5. Figure 11:
Firstly, to me, the evolution of precipitation is better represented in daily mean precipitation than in accumulative precipitation. Figure 11a shows that the CTRL is close to observation in the mid of July for accumulative precipitation. However, it also means that the CTRL has more precipitation from June to Mid-July while the CTRL has less precipitation from Mid-July to the end of August, comparing to

observations. The EXP reproduces better precipitation evolution to me in the monsoon season. Secondly, in term of the aerosol-induced precipitation changes, aerosols increased precipitation by _90 mm (which is _15% to the EXP of _590mm) at the end of August over IN. Over EA, aerosols decreased precipitation by _120 mm (which is _17% to the EXP of _710 mm). Considering the model simulated AOD significantly underestimated as shown in Figure 2 and Figure 3, should we expect that aerosols will change precipitation by _30% although aerosol effects may not be linear? Could the authors discuss the impact of underestimated AOD? The aerosol induced precipitation changes are much larger than the changes shown in other studies (usually less than 10%). Could the authors discuss the discrepancy of the precipitation changes in the literature? Finally, with the increase of AOD close to observations, we may expect the accumulative precipitation in CTRL will not be close to the observations as shown in Figure 11a and 11b. Is one of the main conclusions ("consideration of the local emissions show an improvement in simulated monsoon precipitation") still valid?

➔Response: To further understand the impacts on precipitation. We went further to plot monthly precipitation over EA (or EC as we changed it to EC). See the figure below. Actually, CTRL is doing a good job in simulating precipitation in most months except for May. It is difficult to get perfect results given the uncertainties in this work. So the conclusions in this study still hold true. We included more discussion on the simulated precipitation and the potential impacts of the model results due to the underestimation of AODs.



6. P21402L6: Could the model simulations show that aerosols induce a longer life time of clouds?

➔ Response: Given the model and simulations presented in this work, it is not straightforward to quantify the lifetime of clouds. We have included some discussion on this issue and compared with some literature work.

7. Many important papers in aerosol impacts on Asian monsoon (over India and China) are not cited. In past several years many similar works focusing on aerosol impacts on Asian Summer Monsoon, with both global and regional models, have been done in other groups around the world, a better literature research is needed. See below attached incomplete list.

➔ Response: More references are included.

8. Comparing to previous studies, what's the new insight that readers can get from this study? Please discuss.

➔Response: We discussed this in the "Discussion and Conclusions" section.

Minor comments:

1. Title: The WRF-chem simulations include both anthropogenic and biomass burning aerosols. Previous studies (such as Gu et al. 2006, JGR) have shown that the impacts of anthropogenic and biomass burning aerosols on climate are different. The title is misleading by just including anthropogenic aerosols.

➔Response: We have revised the title to "Influence of anthropogenic related aerosols on the Asian monsoon: A case study using the WRF-Chem model". We also clarify in the revision that the anthropogenic related aerosols include the aerosols from human caused biomass burning.

2. P21385L25: Is the Wang et al. (2009) paper listed in the reference section the right one the authors are referring to?

➔Response: The correct reference of Want et al. (2009) has been added to the reference section.

Wang, C., D. Kim, A. M. L. Ekman, M. C. Barth, and P. J. Rasch (2009), Impact of anthropogenic aerosols on Indian summer monsoon, Geophys. Res. Lett., 36, L21704, doi:10.1029/2009GL040114.

3. P21387L5: Studies such as (Lau and Kim, 2006, GRL; Wu et al., 2013, JGR) shows that horizontal distribution of aerosols is also important to the pathway of aerosol impacts on regional climate.

➔Response: Yes. We acknowledge that horizontal distribution of aerosols is also important. Some discussion on this is added in the revision.

4. P21387L6: The CALIPSO data provides vertical distribution of aerosol extinction and it can be used for the model evaluation.

➔ Response: We have revised this statement "The lack of detailed measurement of aerosol vertical distribution over large scales also limits our understanding of the roles of aerosols in climate." To "The lack of detailed measurement of aerosol vertical distribution over large scales in the past limited our understanding of the roles of aerosols in climate. Recent satellite measurements, i.e. CALIPSO data which provide more detailed aerosol vertical information, would improve our understanding."

5. P21388L23: Is water considered as one of aerosol species?

➔ Response: Yes.

6. P21392L8-9: This sentence is not necessary here. Suggest removing it.

➔ Response: This sentence is removed.

7. P21392L15: Studies have shown that dust contributes to _35% of the total aerosols over eastern China (Zhang et al. 2012, ACP) in the pre-monsoon season and dust could have significant impacts on regional climate there.

➔Response: Yes, we agree with the reviewer that dust aerosols are important. However, in the current study, we did not address dust aerosol impacts. Another study by Kumar et al (2013) went further to improve the model simulations of dust aerosols over Southeast Asia.

Kumar, R., Barth, M. C., Pfister, G. G., Naja, M., and Brasseur, G. P.: WRF-Chem simulations of a typical pre-monsoon dust storm in northern India: influences on aerosol optical properties and radiation budget, Atmos. Chem. Phys. Discuss., 13, 21837-21881, doi:10.5194/acpd-13-21837-2013, 2013.

8. Figure 2: Is there any specific reason that April and July are selected for comparison?
Why not comparing all the simulated months for both pre-monsoon and monsoon seasons?

➔Response: There would be too many figures in Figure 2 if we show the comparison for each month. So we picked every other month.

9. Figure 3: There are many AERONET sites in Asia covering the simulated region.
Why are all the 8 selected sites over eastern China? As India is one of the two interested regions in this study, AERONET sites over India should be selected for comparison.
Change "May-August" to "March-August".
➔ Response: We have checked the AERONET site data in India, but the data over the study period were sporadic. We cannot tell much from the data. Changed "May-August" to "March-August".

10. P21393L25-27: This hypothesis can be validated by including the EXP results in the comparison of surface air temperature.
➔Response: The difference between CTRL and EXP is shown in Figure 6. Surface air temperature from EXP is higher than CTRL almost everywhere. This is further discussed in Section 4.1.

11. Figure 5: Why does it only show precipitation over land?
➔Response: Studies have shown that WRF has a low skill in simulating precipitation over oceans (i.e. Koo and Hong, 2009). We have included this information in the paper.

Koo, M.-S., and S.-Y. Hong: Diurnal variations of simulated precipitation over East Asia in two regional climate models, J. Geophys. Res., 115, D05105, doi:10.1029/2009JD012574. 2010.

12. P21396L14: It is more accurate to call the highlighted region as Eastern China.
➔Response: Eastern Asia has been changed to Eastern China.

13. P21396L15-16 and L22-23: The vertical distributions of aerosols are not shown in the manuscript.
➔Response: The vertical distribution of aerosols is not shown. So we included this information in this sentence. Basically, the vertical distributions of aerosols are quite similar to QNDROP.

"In the pre-monsoon season, over IN, aerosols, the vertical distributions of which (not shown) are similar to those of QNDROP, from local sources are restricted to the near surface layers, resulting in a small increase in cloud droplet number and cloud water mixing ratio at lower levels"

14. What is the horizontal and temporal resolution of the PERSIANN data? Which
TRMM dataset is used in this study, and what is its horizontal and temporal resolution?

➔Response: We have included the following information in the paper:

The daily PERSIANN data used in this study were generated at 0.25° x 0.25° by the ERSIANN system, which was based on geostationary infrared and visible imagery, and the TRMM satellite was used for regular updating of the network parameters ((Hsu et al. 1999; Sorooshian et al., 2000) in the system. The satellites used in the system include GOES-8, GOES-9/10, GMS-5, Metsat-6, and Metsat-7) provided by NCDC, NOAA (Janowiak et al., 2000), and TRMM TMI instantaneous rain product (2A12) of NASA (kummerow et. al., 2000). Sorooshian et al. (2000) compared precipitation estimates from PERSIANN (trained with TMI data) with gauges and radar (as well as several TRMM products) between 30°S–30°N and 90°E–30°W. Over land, they found relatively high correlations against gauges and radar when aggregated to coarse resolutions (1° and 5° grids).

Hsu, K., H.V. Gupta, X. Gao, S. Sorooshian: Estimation of Physical Variables from Multi- Channel Remotely Sensed Imagery Using a Neural N 1etwork: Application to Rainfall Estimation," Water Resources Research, 35(5), 1605-1618, 1999.

Janowiak, J.E., R.J. Joyce, and Y. Yarosh: A real-time global half-hourly pixel resolution infrared dataset and its applications, Bulletin American Meteorology Society, 82, 205-217, 2000.

Kummerow, C., J. Simpson, O. Thiele, W. Barnes, A. T. C. Chang, E. Stocker, R. F. Adler, A. Hou, R. Kakar, F. Wentz, P. Ashcroft, T. Kozu, Y. Hong, K. Okamoto, T. Iguchi, H. Kuroiwa, E. Im, Z. Haddad, G. Huffman, B. Ferrier, W. S. Olson, E. Zipser, E. A. Smith, T. T. Wilheit, G. North, T. Krishnamurti, K. Nakamura: The Status of the Tropical Rainfall Measuring Mission (TRMM) after Two Years in Orbit. Journal of Applied Meteorology, 39(12), 1965-1982, 2000.

Sorooshian, S., K. Hsu, X. Gao, H.V. Gupta, B. Imam, and D. Braithwaite: Evaluation of PERSIANN system satellite-based estimates of tropical rainfall, Bulletin American Meteorology Society, 81, 2035-2046, 2000.

15. P21397L25: The spatial distributions of precipitation from PERSIANN and TRMM don't look "very similar" to me, especially for the pre-monsoon season.
➔Response: We revised that sentence "Overall, the spatial distributions of observed precipitation from PERSIANN and TRMM are very similar over much of the modeling domain, but differ in regional details …" to "Overall, the spatial distributions of observed precipitation from PERSIANN and TRMM are similar over much of the modeling domain in the monsoon season, but differ in the pre-monsoon season in regional details …"

16. P21398L1-3: Is there any reference showing that PERSIANN is better than TRMM?
It is not clear to me why higher spatial resolution will induce better quality of precipitation.
Which satellites are used in the PERSIANN dataset? If the TRMM 3B42 dataset
is used in this study, it also includes multiple satellite products. Please clarify.
➔Response: Please see the response to #14.

17. P21398L18-19: How good is the simulated dust aerosol?
➔Response: The default dust model in WRF-Chem does not perform well over Asia. The more comprehensive evaluation of dust aerosol is presented by another study by Kumar et al. (2013).
Kumar, R., Barth, M. C., Pfister, G. G., Naja, M., and Brasseur, G. P.: WRF-Chem simulations of a typical pre-monsoon dust storm in northern India: influences on aerosol optical properties and radiation budget, Atmos. Chem. Phys. Discuss., 13, 21837-21881, doi:10.5194/acpd-13-21837-2013, 2013.

18. P21399L3-15: I don't see the correlation of OLR and precipitation in Figure 10c
and 10d.
➔ Response: The patterns of changes in OLR are not the same as those in precipitation as the precipitation used here is accumulative. If we use daily precipitation, the patterns in precipitation would be less clear. So we used accumulative precipitation. However, we still can see from the two sets of figures that the location where when OLR starts to decreases/increases shows increases/decreases in precipitation.

19. Please give the units of all variables in all the plots.
➔Response: Thanks for pointing out this. We have included units for all variables shown in the plots.

References:

Giorgi, F., X. Bi, and Y. Qian (2002), Direct radiative forcing and regional climatic effects of anthropogenic aerosols over East Asia: A regional coupled climate-chemistry/aerosol model study, J. Geophys. Res., 107(D20), 4439, doi:10.1029/2001JD001066.

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Li, Z., et al. (2011), East Asian Studies of Tropospheric Aerosols and their Impact on Regional Climate (EAST-AIRC): An overview, J. Geophys. Res., 116, D00K34, doi:10.1029/2010JD015257.

Liu, X., L. Yan, P. Yang, Z.-Y. Yin, and G. R. North, 2011: Influence of Indian summer monsoon on aerosol loading in East Asia. J. Appl. Meteor. Climatol., 50, 523–533.

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Wu, L., H. Su, and J. H. Jiang (2013), Regional simulation of aerosol impacts on precipitation during the East Asian summer monsoon, J. Geophys. Res. Atmos., 118, 6454–6467, doi:10.1002/jgrd.50527.

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Zhang, X. Y., Wang, Y. Q., Niu, T., Zhang, X. C., Gong, S. L., Zhang, Y. M., and Sun, J. Y. (2012): Atmospheric aerosol compositions in China: spatial/temporal variability, chemical signature, regional haze distribution and comparisons with global aerosols, Atmos. Chem. Phys., 12, 779-799, doi:10.5194/acp-12-779-2012.