

Review of “Influence of anthropogenic aerosols on the Asian monsoon: a case study using the WRF-Chem model” by Jiang et al.

General Comments

This study used the WRF-Chem model to investigate the direct and indirect effects of anthropogenic aerosols on the Asian monsoon system during the period of March-August 2008. The simulation is evaluated by comparing the simulated aerosol optical depth and meteorological fields with the satellite and reanalysis data. The sensitivity experiment was designed to examine the direct and indirect effects of anthropogenic aerosols on the precipitation, surface temperature, radiation, and circulations in pre-monsoon and monsoon period. The authors also want to answer what are the aerosols-cloud-precipitation interactions during Asian monsoon season. In general, they found anthropogenic aerosols tend to reduce precipitation in the source regions while slightly increase precipitation outside the aerosol source regions. Anthropogenic aerosols also induced a reduction in pre-monsoon and monsoon precipitation over East Asia.

Aerosol can play an important role in the climate system and interact with cloud and precipitation. It will be interesting and important to investigate aerosol impact on Asian monsoon precipitation and circulation. However, I cannot trust the results that the authors showed based their experiment design. Without ensembles or multi-year simulations, the aerosol impact “signal” is just too weak (e.g., Fig. 10). Most of the difference between two experiments may be just the noisy due to the chaotic behavior of weather or climate. The ensemble-mean of the impact could be significant different from what they had now. Most of their explanation of the modeling results is very subjective or just based on previous studies. In their version of WRF-Chem (v3.3.2), the aerosol indirect effect cannot be fully investigated. It missed aerosol impact on cloud ice nucleation and convective cloud microphysics. Most of the cloud and precipitation changes may be mainly due to aerosol direct and semi-direct effect. I have some specific comments below.

Major Comments

- In v3.3 of WRF-Chem, the aerosol impact on the convective cloud microphysics is not included in the cumulus parameterization. Therefore, the simulation at a horizontal resolution of 42 km that cannot resolve convective clouds shouldn't be used to investigate aerosol indirect effect, particularly for the monsoon season when convective events are active.
- The statistical analysis must be done for the signal of aerosol impact on cloud and precipitation.
- This work also tended to investigate the influence of dust aerosol on cloud and precipitation over West India and North China. The authors said, "The impacts due to dust aerosols are much smaller as compared to the effects from anthropogenic aerosols. There is a small increase in precipitation in the Indian region, and the changes in East Asia are different in different seasons". However, I cannot find any evaluation of the dust simulation (It is blank over the dust source regions, such as the Taklimakan Desert and Gobi desert in Figure 2). It may be because authors argued the default dust emission scheme is too poor. Please add the evaluation of dust simulation; otherwise the discussion about the dust effect should be removed. There is already a new emission scheme based on GOCART dust emission scheme coupled with the MOSAIC aerosol module in v3.3. There is some evaluation of its performance over Asia (e.g., Chen et al., 2013). You can use that scheme to investigate the dust climate impact if you want. In addition, could you please explain why the dust-induced precipitation changes have the opposite patterns in pre-monsoon and monsoon periods (Figure 9)?
- There is another similar study, Wu et al. (2013), also using WRF-Chem to investigate aerosol impact on East Asian monsoon. What is the difference between this study and theirs? Authors, at least, need discuss the results from Wu et al. (2013). Need more discussion about the results from previous studies and this study. Why is this study unique if a regional modeling study has been done by Wu et al. (2013)?
- The presentation of the results includes an evaluation of the aerosol optical depth and meteorological fields. I would suggest adding an observation section that describes the satellite, AERONET, and reanalysis data.

- The comparison between the WRF-Chem and AERONET is too poor during your study period. I am worried about the conclusion about the aerosol impact found in your study. WRF-Chem can simulate much better results than what you presented (e.g., Gao et al. 2011). In addition, 2008 is a year of Beijing Olympic Game. China government conducted emission control. It needs to be discussed about the uncertainty of emission inventory without counting this effect.
- In Figure 5, why not show precipitation over the ocean?

Minor Comments

- Lines 4-7 of page 21402, the results from Chapman et al. (2009) may not be the case in this study, since they design relatively high resolution (up to 2 km) experiments that can properly resolve most clouds, which is not the case in this study.
- Lines 14-17 of page 21402, aerosol impact is important, however, it is hard to be proven by your analysis with inappropriate experiment design.
- Figure 2: please provide the seasonal-averaged AOD for pre-monsoon and monsoon seasons in 2008 from MISR/MODIS and WRF-Chem results.
- The MODIS deep-blue products are preferred for the comparison with simulated AOD over land.
- Figure 3: It will be better to plot AERONET data in black dots to distinguish them with blue solid lines.
- Figure 4: “surface temperature” and “2-m temperature” are the different variables in the WRF model.
- Figure 6: Could you please explain the large increased surface air temperature in Mongolia during the monsoon season?
- Page 21395 line 2: please keep the temperature unit consistent with Figure 6.
- Figure 7: Please add a brief explanation of why select the highlighted regions, IN and EA.
- Figure 7: Please convert “sigma level” into “Pressure” or “Altitude” in the y-axis.
- Figure 10: Lines 13-15 of page 21399 “Figure 10c and d shows that the changes in the precipitation evolution strongly correlate with the evolution of OLR changes in

the two regions, with higher OLR corresponding to lower precipitation.” It is hard to be seen from this Figure.

References:

Wu, L. et al.: Regional simulation of aerosol impacts on precipitation during the East Asian summer monsoon, JGR, 2013.

Chen, S, et al.: Modeling the Transport and Radiative Forcing of Taklimakan Dust over the Tibetan Plateau: A case study in the summer of 2006, JGR, 2013.

Gao Y, et al.: Emission Controls Versus Meteorological Conditions in Determining Aerosol Concentrations in Beijing during the 2008 Olympic Games, ACP, 2011.