General comments:

In the current work, the authors used WRF-Chem with IPR analysis and sensitivity tests to assess the effect of vertical distribution of BC on meteorology and surface $PM_{2.5}$ concentrations during Beijing haze episodes. The research topic is very well suited to the scope of the current journal and the results presented are very interesting to their readers. However, there are some uncertainties, especially in the methodology, that require some modification before it is accepted. Without a concrete explanation of the methodology, the reviewer is uncertain whether the model settings chosen by the author will actually answer the authors' research questions. See the general and specific comments listed below.

1. There are no presentations on clouds and precipitation throughout the manuscript. In the presence of clouds and precipitation, the radiation effect of aerosols is quite different from that of sunny days. Please show and compare measured and simulated clouds, precipitations, or solar radiation.

Specific comments:

*Abstract:*

2. The authors simply repeated "$PM_{2.5}$ concentration", but more specifically, "$PM_{2.5}$ surface air concentrations" ($PM_{2.5}$ can be aloft). Please define "$PM_{2.5}$ concentration" as "surface air concentrations of $PM_{2.5}$" when it is first appeared.

3. P. 8, Ln. 154, "NCEP": Please be more specific. For example, specify the datasets number.

4. P. 9, Ln. 168, "FINN": Please provide horizontal and temporal resolution.

5. P. 10, Ln. 189, "updrafts": The convection scheme also includes downdrafts and precipitation. Which parameterization did you use for convection? Please list it in Table 1. The subgrid-scale wet deposition is calculated in the convection model so they can be counted as CONV here, but they need to be count as WET (wet deposition).

6. P. 10, Ln. 192, "cloud": How do you separate cloud chemical formation from in-cloud scavenging? The formation of $PM_{2.5}$ due to cloud chemistry occurs only when the cloud and rain droplets are completely evaporated. On the other hand, $PM_{2.5}$ in the cloud and

rain droplets are not counted as $PM_{2.5}$ and are removed from the air (although they are not completely removed unless droplets reach the ground).

7. P. 10, Ln. 194, “WET represents the wet removal processes of aerosols”: In-cloud and below-cloud? Again, how do you separate “cloud” in CHEM from in-cloud scavenging in WET here?

8. P. 10, Ln. 195, “OTHER”: What are they? Dry deposition should be the one but any other processes?

9. P. 10, Ln. 202: “Beijing station”, where is it and what does it belong to? Does the station belong to NOAA? Maybe not, but the data was obtained from NOAA’s website.

10. P. 10, Ln. 205, PBL of GDAS: what is the horizontal resolution of GDAS? Even though the GDAS is the analysis (or one can call it observation), is their PBL also assimilated with observed PBL? If not, PBL of GDAS cannot be regarded as observation as you show in Fig. 5. If it is assimilated with observed PBL, please specify which observation data was assimilated.

11. P. 12, “indirect radiative effects”: how? The authors used the Lin’s scheme for cloud microphysics, which is a single moment scheme and thus cloud albedo and cloud lifetime effects are not considered. Is it intended simulation settings?

12. P. 15-16, discrepancy of vertical profiles on December 11: Are the observation and simulation average times same? The simulated profile appears to be at night or very stable during the day, but the observed profile looks only be during the day.

13. It is necessary to discuss the reason for the difference in vertical profile between the simulation and observation on December 11th. Judging from the profile, the simulated surface air concentration is four times the observed value, but the overestimation of the simulated surface $PM_{2.5}$ concentration is not so high (Fig. 3). The simulated night T2 of the day has a significant overestimation (+6 deg C). It is 0 deg C in the simulation and -6 deg C in the observation. Is it due to overprediction of simulated clouds to prevent radiative cooling at night?

Figures

14. Caption of Fig. 1, “The BC vertical profiles were modified for the red box which covers …” should be written in the main text.

15. Fig. 2, “blue and red squares” are hardly legible.

16. Fig. 2(j), Does “Beijing” mean spatial average of the blue square region? Or one grid of the center of Beijing region? Please specify. Throughout the manuscript, it is hard to get whether the authors indicate values of only one grid point, one observation site, or those of spatial average.

17. Fig. 3, “Beijing”. Again, Beijing point or Beijing area? Both for simulation and observation.

18. Fig. 3: Even though the model did not consider SOA, the simulated $PM_{2.5}$ was in perfect agreement with what was observed. Is the SOA negligibly small compared to the POA during the observation period, or do the OM/OC ratio(s) assumed for OC emission in the simulation well represent those of SOA and POA in the BTH region? Specify the number of OM/OC ratio(s) used in the simulation and how the author determined the value(s).

19. Caption of Fig. 4: What time? Both for observation and simulation.

20. Fig. 5: Can you compare downward solar radiation at ground surface here? It could also effectively evaluate the model performance of aerosols, and even clouds.