General comments:

Zhang et al. conducted a study to investigate the chemical composition and source apportionment of $PM_{2.5}$ in three cities in northern China. The aim was to provide suggestions for the development of effective policies to improve air quality in the future. The researchers employed online instruments such as Q-ACSM, AE33, and Xact625 to monitor the chemical components of $PM_{2.5}$. Additionally, they used a new receptor model to identify the sources of $PM_{2.5}$. The study also discussed the potential formation mechanisms of secondary aerosols and the progress of heavy pollution. Zhang et al. emphasized the significance of controlling biomass burning and inhibiting the generation of secondary aerosols. In summary, this paper offers important insights into the sources and controlling factors of $PM_{2.5}$ pollution in the three northern Chinese cities during winter, providing valuable information for the development of air quality improvement policies in the near future. I recommend the publication of this manuscript in ACP; however, some revisions are necessary prior to its publication.

Major comments:

In terms of the source apportionment of $PM_{2.5}$, the authors characterized the secondary source as having a high loading of $SO_4^{2-}/NO_3^-/NH_4^+$, which are inorganic aerosols. The manuscript identifies the secondary source as secondary sulfate plus nitrate. However, it does not address the contribution of secondary organic aerosols in the source apportionment. It is important for the authors to address this issue and discuss how they considered the contribution of secondary organic aerosols.

In Section 3.5, the authors compare $PM_{2.5}$ source apportionment results with those of previous academic studies conducted in Beijing over the past decades. Additionally, the Beijing Municipal Bureau of Ecology and Environment has released some official results of $PM_{2.5}$ source apportionment. It would be beneficial for the authors to include these official results in their comparative analysis, along with the results from previous academic studies.

Specific Comments:
1. line 18: "explore"→ "explored", and delete "process"
2. line 42-43： "the China central government implemented the Air Pollution Prevention and Control Action Plan (APCAP) in September 2013"， here change "implemented" to "issue"， or change "in September 2013 " to "since September 2013"
3. line 57： "improve furtherly" → "further improve"
4. line 85： change "the National Ambient Air Quality Standards (NAAQS)" to

"China's National Ambient Air Quality Standards (NAAQS-II) of 35 μg m-3"

5. line 89: change "NAAQS" to "NAAQS-II", change "unclear to" to "unclear about"

6. line 233: "To have a better understanding of " → "To   better understanding   the impact of"

7. line 290:   "It should be note that " → "It should be noted that "

8. line338: delete "simply"

9. line340:   "concentration levels of gas pollutants" → "the concentration levels of gaseous pollutants"

10. line342: "the fresh emissions" → "fresh emissions"

11. line 343-344: change "The two dominant chemical components in PM2.5 during all pollution episode cases were OA and NO3-" to "OA and NO3- were two dominant chemical components in PM2.5 during all pollution episode cases"

12. line 345: "by the prohibiting of" → "because of the prohibiting of"

13. line352: change "To profoundly understand" to "To gain insights into"

14. line334-355: The sentences of "For the first type of episode represented by EP4 (Fig. S14), a two-stages evolution was distinguished" was awkward, please rewrite.

15. line358: "demand" → "activities"

16. line366: "predominant" → "the predominant"

17. line368: add "in the study period" after "wind speed"

18. line372: "In which" cannot be used at the beginning of a sentence.

19. line376: "while" → "in which"

20. line 380: "contributed" → "attributed"

21. line383&385: "with dominant increase of…" → "with a dominant increase of ..."

22. line390: "event" → "events"

23. line394:   " plays more important role " → " plays a more important role" and "in which" is not appropriate here

24. line396: "priority" → "the priority"

25. line397: "reducing" → "reduce", "precursors" → "the precursors"

26. line 405: change "… This led a decrease of…" to ", which lead a decrease of…"