Response to reviewer 1#:

We thank the reviewer for the thoughtful comments and for the proposed corrections to improve our paper. Accordingly, we have revised the manuscript carefully and our point-to-point responses to the reviewer's comments are given below.

General comments: This paper characterizes the aerosol physical, chemical, and optical properties and implication of visibility during an intense haze episode in Beijing winter. Heavy haze episodes occur more frequently in Beijing and the Great North China Plain. The manuscript provides numerous information on aerosol physicochemical properties and the effect on visibility due to these haze particulates. It is useful to quantitatively estimate the aerosol direct radiative forcing under heavy haze cases. Obviously, there are numerous grammatical and technical errors in the manuscript. This paper is reconsidered to be acceptable and published after major revisions.

Specific comments: (1) Abstract, lines 20-24: "Light scattering apportionment showed C8492 that organic. . .. . .contributed to light scattering fractions of 57%. . .. . .,, respectively. This study indicated that the organic component in submicron aerosol plays an important role in visibility degradation in this haze episode in and around Beijing". âG˘ Š As is well known that, both of scattering and absorption of aerosol particles can degrade thevisibility. Many studies also found that urban aerosols under haze events in Beijing did have moderate absorption of solar light, which means that the absorption of aerosols may contribute to the visibility degradation. Therefore, to strongly support this conclusion, the authors should provide the visibility data versus

organic compound during the haze episode in the context.

Response: Thanks for the suggestion. During the observation periods, visibility measurement is not carried out by us. However, we obtained the visibility data in one hour resolution in the website for reference (http://www.wunderground.com/history/). The visibility data versus organic compound during this haze episode is showed bellowing. We should demonstrate that the visibility range is 30 Km and some gaps exist during 24 and 25 of January. For this, we added this picture in our supplementary materials and we also added interpretation in our revised manuscript.

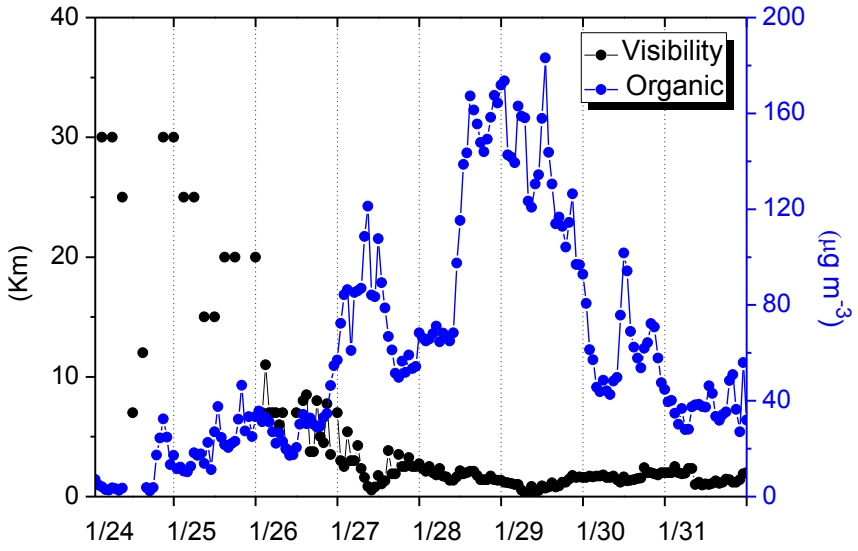


Figure S6 Time series of visibility and mass concentration of organic matter during this haze episode

(2)Introduction, lines 13-14: ". . ., though the total aerosol mass concentration has decreased in Beijing in the last ten years." âG˘ Š What does the "total aerosol mass concentration" mean? Total suspended particulate (TSP), PM10 or the others? Please make clarify and add the citation of publications.

Response: The total aerosol mass concentration means PM10 mass concentration. According to our longtime observation, the annual mean PM10 mass concentration in Beijing was 141μg m^{-3} in 2004, while it decreased to 134 μg m^{-3} in 2012 (Liu et al., 2015).We clarified this in our revised manuscript.

(3)Results and discussion, Page 23381, Lines 18-19: "Particularly at 08:00 of 28 January (Beijing time), the lapse ratio of temperature is nearly -6_/100m, which means a very stable synoptic condition". âG˘ Š This sentence makes contradictory with the Figure3. Generally, the lapse rate of air temperature is about -6â˘DC˘ /100m on the global continent.

Response: Thanks for the correction; we have modified this as 0.6℃/100m in our revised manuscript.

(4)Pages 23380-23381, Lines 25-26: ". . ., indicating that PM1 dominated the total mass of aerosol particles". And in Page 23383, Lines 9-10: ". . ., which indicated a more dominant coarse particle mode compared with the other locations." âG˘ Š The two conclusions are contradictory and would confuse the readers. Please clarify it.

Response: Thanks for the comments. In pages 23380-23381, we want to express that PM1dominated the total mass before January 28. According to figure 1,it is easy to recognize. In page 23383, we want to express that coarse particle dominated during the whole observation period.

(5)Page 23384, Lines 5-6: ". . ., which indicates an increasing fraction of relative coarse aerosol, consistent with the variation pattern of PM1/PM2.5 showed in Fig. 1b." âG˘ Š Please give a short interpretation about this conclusion.

Response: During 28, 29 and 30 of January, the measurements from the nephelometer showed increased fraction of coarse particle, consistent with the variation of decreased ratios of PM1/PM2.5 showed in figure 1b, which means that the mass fraction of PM1-2.5 increased.

Minor comments:

(1) Title: "Aerosol physicochemical properties and implication for visibility during an intense haze episode during winter in Beijing" âG˘ Š Change to C8493 "Aerosol physicochemical properties and implication of visibility during an intense haze episode in Beijing winter".

Response: We accept your suggestion.

(2)Page 23375, the affiliation of the authors: "Chinese Academy of Science" âG˘ Š Change to "Chinese Academy of Sciences" Change "College of Atmospheric Science" to "College of Atmospheric Sciences"

Response: Thanks for the correction.

(3)Abstract,line 3: change "during an extreme haze episode in Beijing" to "during an extremely intense haze episode in Beijing"

Response: Thanks for the correction.

(4) Symbols such as PM1, PM2.5 and PM10 in the abstract are not explained.

Response: We have added those explanations in our revised manuscript.

(5) Abstract, line 7: change "during the most heavily polluted periods" to "during the most heavily polluted period"

Response: Thanks for the correction

(6) Abstract, lines 7-8:“The average scattering coefficient at 550 nm was 877±624 Mm-1”

Response: Thanks for the correction

(7) Abstract,line 12: “accumulation mode”

Response: Thanks for the correction

(8) Abstract, line 14: “the mass concentrations of”

Response: Thanks for the correction

(9)Abstract, line 16: “contributed greatly to the growth of particles during the heavily polluted day (28 January)”

Response: Thanks for the correction

(10) Abstract, lines 17-20: “Increasing relative humidity and stable synoptic condition combined with heavy pollution on 28 January, led to enhanced water uptake by the hygroscopic submicron particles and formation of secondary aerosols, which might be the main reasons for the severity of the haze episode.”

Response: Thanks for the correction

(11) Abstract, lines 22-24: “This study indicated that the organic component in submicron aerosol played an important role in visibility degradation during the hazeepisode in Beijing.”

Response: Thanks for the correction

(12) Introduction, line 2: “Atmospheric aerosol particles play a significant role in. . .”

Response: Thanks for the correction

(13) Introduction, line 4: “Ramanathan et al., 2001). In addition, they can act as. . .”

Response: Thanks for the correction

(14) Introduction, line 6: “clouds are indirectly influenced by aerosols. . .”

Response: Thanks for the correction.

(15) Introduction, line 8: “due to its deleterious effect. . .”

Response: Thanks for the correction.

(16) Introduction, lines 12-14: “. . .has suffered substantially from the deterioration of air quality and the degradation of visibility, though the total aerosol mass concentration has decreased in the last ten years (please add the citation).”

Response: Thanks for the suggestion and we have added a citation (Liu et al., 2015) in the revised manuscript.

(17) Introduction, lines 16-20: “The frequency of visibility between 2 km and 10 km has increased from 37% in 1999 to 43% in 2007 (Zhang et al., 2010). The mass loading of fine aerosol particles andtheir precursors (e.g., NH3, volatile organic compounds (VOCs), SO2 and NOx). . .and strong temperature inversion (Zhang et al., 2013).”

Response: Thanks for the correction.

(18) Introduction, lines 21-23: “In the past decades, many researches have been done to characterize the chemical C8494 and physical properties of aerosol particles in Beijing and its surrounding regions. These studies mainly focused on the following aspects:”

Response: Thanks for the correction.

(19) Introduction, line 28:The symbol of MODIS is not explained.

Response: We have added those explanations of MODIS in our revised manuscript.

(20) Page 23378, lines 8-14: “The above mentioned studies, based on either long-term or short-term observations provided uswith comprehensive knowledge of aerosol properties with near average. . ..However, only a few studies were carried out under highly polluted days, and these studies mainly focused on. . ..boundary layer dynamics (Huang et al., ...). The interaction between chemical and physical properties of aerosol was seldom. . .”

Response: Thanks for the correction.

(21) Page 23378, lines 17-18: “during pollution episodes.”

Response: Thanks for the correction.

(22) Page 23378, line 20: Change “averaged” to “average”, and modify the other place in the manuscript.

Response: Thanks for the correction.

(23) Page 23378, lines 21-26: “which was the . . ..as we know. In this study, we investigated the evolution of physical, chemical, and optical properties of urban aerosol particles during the haze episode by using the in-situ measurements.”

Response: Thanks for the correction.

(24) Page 23379, line 2: “2.1 Site information and instrumentation”

Response: Thanks for the correction.

(25) Page 23379, lines 3-5: “The aerosol sampling site was situated on the roof (about 15 m height above the surface) of . . ., Chinese Academy of Sciences, which was located between. . .”

Response: Thanks for the correction.

(26) Page 23379, lines 9-11: “angles between 7-170_) of low relative humidity (RH) aerosol at wavelengths of 450, 550 and 700 nm, respectively, without size-selective inlet. The nephelometer was operated at 5 Lmin-1 with time resolution of 1 minute.” According to (Anderson and Ogren, 1998), the correction factors of Angular Nonidealities for the nephelometer without size-selective inlet should be considered at different wavelengths, please add the discussion in the manuscript.

Response: Thanks for the suggestion. We have added this in the revised manuscript. Light scattering efficiency is sensitive to particles with similar diameter with visible range. The nephelometer is not equipped with size-selective inlet and some coarse particle will in to the nephelometer. However, these particles have limited scattering efficiency compared with that in 100nm-1000nm. If any, we think these coarse particles may have more influence on 700nm than 450nm.

(27) Page 23379, line 14: No reference of “(Anderson and Ogren, 1998)” is found.

Response: We have added the reference in our revised manuscript.

(28) Page 23379, line 20: “between 14 nm and 2500 nm”

Response: Thanks for the correction.

(29) Page 23379, line 21: “comprising of . . .”

Response: Thanks for the correction.

(30) Page 23379,line 24: “The SMPS data covered the particle sizes range from 14to 533 nm”

Response: Thanks for the correction.

(31)Page 23379, lines 25-26: Please give a short discussion about "the size-dependent diffusional and gravitational losses for the inlet line were corrected by using the empirical functions"

Response: According to our study, the diffusion loss was estimated to be ~20% for the smallest measureable particles of 14.5nm, diffusion loss could be negligible for particles between 100nm to 1000nm, and estimated to be ~3% for particles of 2.5 μm.

(32) Page 23379, line 27: Change "was" to "were"

Response: Thanks for the correction.

(33) Page23380, line 1: "according to the methods of "

Response: Thanks for the correction.

(34) Page 23380, line 6: submicron C8495 particle mass-size distributions"

Response: Thanks for the correction.

(35) Page 23380, line 10: "(e.g., NO, NOx, CO, O3 and SO2)"

Response: Thanks for the correction.

(36) Page 23380, lines 12-13: "were given by Tang et al. (2012) and Wang et al. (2014b)."

Response: Thanks for the correction.

(37) Page 23380, lines 15-17: "was used to obtain meteorological parameters (e.g., relative humidity, air temperature, wind speed and direction). The time base for all data in this study was Beijing zone time (=UTC+8)"

Response: Thanks for the correction.

(38) Page 23380,lines 20-26: "Figure 1 shows the time series of . . .during the period.

The average mass concentrations of . . ., respectively, indicative of the high level of aerosol pollution. The average mass ratios of. . ., respectively. As we can see in Fig. 1b, the mass ratioof PM1/PM2.5 is higher than that of PM2.5/PM10 before 28 January, indicating thatPM1 dominated the total mass of aerosol particles."

Response: Thanks for the correction.

(39) Page 23381, line 1: Please move the "lines 20-28" before the "Figure S1 in the Supplement displays. . .".

Response: Thanks for the correction.

(40)Page 23381, line 1: Figure S1 in the Supplement did not give the marked scale of the wind speed.

Response: Thanks for the correction and we have added the marked scale of the wind speed in the revised manuscript..

(41) Page 23381, lines 2-5: "During this period, the average wind speed is 2.5 ms-1. Figure S2 shows an overview of wind rose of the local wind and the wind is mainly in the southerly and northerly quadrant, which can bring relatively dirty or clean air masses, ...72h backward trajectories of air parcels. . ."

Response: Thanks for the correction.

(42) Page 23381,lines 8-9: "Beijing often suffers more polluted atmosphere than that in the northern area due to more dense cities and population. The clusters of 1 to 5 are from northerndirection, with. . ."

Response: Thanks for the correction.

(43) Page 23381, line 10: Change "Also" to "Furthermore"

Response: Response: Thanks for the correction.

(44) Page23381, line 12: Change “local direction” to “local directions”, change the “most” to “highest”

Response: Thanks for the correction.

(45) Page 23381, line 16: Change “different color” to “different colors”

Response: Thanks for the correction.

(46)Page 23381, line 17: Change “at 1000 m to 1500 m” to “between 1000 m to 1500 m”

Response: Thanks for the correction.

(47) Page 23381, lines 18-19: “the lapse rate of temperature is nearly -6â˘DC˘/100m,”

Response: Thanks for the correction.

(48) Page 23381, line 21: “and 620.8 μg/m-3, respectively.”

Response: Thanks for the correction.

(49) Page 23381, line24: “showed opposite pattern with time. . .”

Response: Thanks for the correction.

(50) Page 23381, line 25: “compared withPM2.5”

Response: Thanks for the correction.

(51) Page 23381, lines 26-28: “compared with PM10 with increasing aerosol pollution. It is worth noting that the increase of PM1-2.5 was greatest during the period from 28 to 29 January, as showed in Fig. 1a.”

Response: Thanks for the correction.

(52) Page 23382, line 1: “3.2 Aerosol optical properties”

Response: Thanks for the correction.

(53) Page 23382, lines 3-7: “measured by the nephelometer. And C8496 the aerosol . . ..can be calculated from the scattering coefficients, which have rarely been reported in Beijing using in-situ measurements. The light scattering coefficients of aerosols show . . .as mass concentrations of PM. . .”

Response: Thanks for the correction.

(54) Page 23382, lines 8-18:“during this haze episode, and the average scattering coefficients. . ..After converting the aerosol scattering coefficients at 550 nm to that of 525 nm, the average at 525 nmare 3.2 times greater than the yearly average values at another urban site in Beijing, reported by He et al. (2009). . .., respectively, as presented in Fig. 4b. During. . .three wavelengths are highly correlated. Both. . .increase gradually from 24 to 29 January and decrease sharply to lower levels, which are consistent with the variations of aerosol mass concentrations.”

Response: Thanks for the correction.

(55) Page 23382, lines 21-22: “by particles. It is related to particle size distributions, and can be calculated as following:”

Response: Thanks for the correction.

(56) Page 23382, line 25: Change “small sized particles” to “small size particles”

Response: Thanks for the correction.

(57) Page 23383,line 2: Change “can be” to “is”

Response: Thanks for the correction.

(58) Page 23383, line 5: Change “as follows;” to “asfollowing:”

Response: Thanks for the correction.

(59) Page 23383, line 7: “and 0.94±0.3, respectively. The average. . .”

Response: Thanks for the correction.

(60)Page 23383, lines 8-10: “Which is smaller than that of 1.46 in Guangzhou (Garland et al., 2008) and 1.7 in Spain reported by Titos et al. (2012), which indicates a more dominant coarse mode particles compared with the other locations.”

Response: Thanks for the correction.

(61) Page 23383, lines 17-20: “between -1 of completely backscattered light to +1 for completely forward scattered light. Because there is no measurements can be directly obtained the values of g, a fit equation applied by Andrews et al. (2006) was used as in Eq. (4).”

Response: Thanks for the correction.

(62) Page 23383, line 23: “0.54±0.05, respectively.”

Response: Thanks for the correction.

(63) Page 23384, lines 1-5: “..shows higher values, which shows lower ones, as showed in Fig. 4. However, the opposite feature occurs when the haze developed. Especially during the highest pollution periods (from 28 to 30 January), higher values of and lower values of and appear, . . . ”

Response: Thanks for the correction.

(64) Page 23384, lines 5-6: “which indicates an increasing fraction of relative coarse aerosol, consistent with the variation pattern of PM1/PM2.5 showed in Fig. 1b.” âGˇ ŠPlease give a short interpretation about this conclusion.

Response: During 28, 29 and 30 of January, the measurements from the nephelometer showed increased fraction of coarse particle, consistent with the variation of decreased ratios of PM1/PM2.5 showed in figure 1b, which means that the mass fraction of PM1-2.5 increased.

(65) Page 23384, lines 8-14:"The particle number-size distribution from 25 to 31 January is shown in Fig. 5. The particle number concentration peaks at a diameter of around 100 nm. These particles C8497are mainly from direct emissions of vehicles,. . ..(Shi et al., 2001). The time series of nucleation mode. . .concentrations are presented in Fig. 6. The Aitken mode particles shows the highest number concentrations during the period. . ."

Response: Thanks for the correction.

(66) Page 23384,lines 16-27: "The lowest particle number concentration is in coarse mode. . ..The Nucleation mode and accumulation mode also show high number concentrations, ...,respectively. Compared with that at another urban site in Beijing, . . .and accumulation mode during this haze episode are 170 times, 10 times and 120 times, respectively(Hu et al., 2009). The nucleation and Aitken mode particles show a significant increase at mid-day on 28 January, while the accumulation mode is not significant. This may be ascribed to the emissions from vehicle and cooking nearby our sampling site. It is worth nothing that the concentration of coarse mode particle is highest on 29 January, . . ."

Response: Thanks for the correction.

(67) Page 23385, lines 1-2: "and Aitken mode particles decrease on 12:00 LT of 30

January, as shown in Fig. 6."

Response: Thanks for the correction.

(68) Page 23385, line 4: "The time series of chemical compositions, mass fractions, O:C ratio and m/z 44 of NR-PM1 are presented. . .", please also give the explanations of O:C ratio and m/z 44.

Response: The O:C ratio is the elements of oxygen and carbon in the aerosol particle. It is a symbol of oxidation level of organic aerosol. The m/z 44 is the signal of secondary organic aerosol from aerosol mass spectrometer.

(69) Page 23385, lines 7-10: "and 5.5±4.2 μg/m-3, respectively. The organic component is dominant in NR-PM1, ...Sulfate and nitrate species concentrations are also very high during the heavy haze event."

Response: Thanks for the correction.

(70) Page 23385, lines 11-15: ". . .size-resolved chemical compositions of different mode particles as a function of time. Figure 8 shows the temporal variations of the size distributions of the organic. . .and chloride (e). The organic and chloride containing particles display a slightly broader distribution than the other three species. All the aerosol components mainly. . .."

Response: Thanks for the correction.

(71) Page 23385, lines 19-21: "Based on the research by Zhang et al. (2004) in Pittsburgh PA, USA, an average aerosol bulk density of 1.5 is assumed in this study. For a first approximation,. . ...to 470 nm in physical diameter of spherical particles."

Response: Thanks for the correction.

(72) Page 23385, line 24:Change “will lead to high light scattering” to “will lead to strong light scattering”

Response: We have added those explanations of MODIS in our revised manuscript.

(73) Page 23385, lines 26-28: “These five aerosol components all show high . . ..28 January to noon of 29 January, corresponding. . ..light scattering of the whole pollution period.”

Response: Thanks for the correction.

(74) Page 23386, lines 2-3: “The particle number concentrations show a burst. . .”

C8498

Response: Thanks for the correction.

(75) Page 23386, line 5: “formation event, which was accompanied by advection of local emissions.”

Response: Thanks for the correction.

(76) Page 23386, line 7: “on 28 January is observed by AMS asshown in Fig. S4. The. . .”

Response: Thanks for the correction.

(77) Page 23386, lines 9-11: “This may be due to the accumulation of air pollutants under the stagnated boundary layer. As we can see in Fig. S1, the meteorological parameters are characterized. . .”

Response: Thanks for the correction.

(78) Page 23386, lines13-15: “the dilution causes the aerosol concentrations decreasing in the afternoon.The concentrations of sulfate, ammonium and nitrate

show an increasing trend from18:00 LT. The major reasons are: (1) Increasing RH. . .”

Response: Thanks for the correction.

(79) Page 23386, lines 19-20:“All of the above aspects result in the mass concentrations of sulfate and ammonium have a distinct the growth of particles with diameters between 100 nm and 500 nm on28 January.”

Response: Thanks for the correction.

(80) Page 23386, line 23: “Figure 10 shows the variations of signal. . .”

Response: Thanks for the correction.

(81) Page 23386, lines 25-27: “. . .are presented as well. The highest. . ..aerosol concentration appears nearly between 20 to 35 μg/m-3, . . .The signal of m/z 44 shows an increasing trend. . .”

Response: Thanks for the correction.

(82) Page 23387, lines 1-4: “component mainly exists at RH below 40%, which is indicative of . . .in urban Beijing. It is notable that the higher levels of the organic component occurs under high RH conditions, of which aerosol water uptake ability is enhanced and the more highly hydrated particles are able to. . .”

Response: Thanks for the correction.

(83)Page 23387, line 6: Change “increased” to “increases”

Response: Thanks for the correction.

(84) Page 23387, line 8: “also show that aqueous-phase processes are responsible for the production of . . .”

Response: Thanks for the correction.

(85) Page 23388, line 15: Delete the “can be”.

Response: Thanks for the correction.

(86) Page 23388, line 18: “AMS can only provide us with mass concentrations. . .”

Response: Thanks for the correction.

(87) Page 23388, lines 27-28: “In IMPROVE algorithm, . . ., while the contribution of organic aerosol didn’t take into account.”

Response: Thanks, we have corrected it

(88)Page 23389, line 10: “as shown in Fig. 13. . .”

Response: Thanks, we have corrected it

(89) Page 23389, lines 19-22: “Yao etal. (2010) showed that the organic components were contributed greatly to the lightextinction (about 45% contribution) by using AMS data during winter in Shenzhen,PRC. Waston (2002) also found the organic aerosol dominated light extinction insome cities, with fractions of 9-50% in eastern USA.”

Response: Thanks, we have corrected it.

(90) Page 23390, lines 2-7:“Based on in-situ measurements, the physical and chemical properties of. . .were characterized during a severe haze episode in Beijing from 24 to 31 January, 2013.C8499The average. . .265.2±157.1 μg/m-3, respectively, and an increasing. . ...during themost heavy pollution period. The average scattering coefficient at 550 nm was. . ..”

Response: Thanks, we have corrected it.

(91) Page 23390, line 14: “contributed to the growth of particle during the most. . .”

Response: Thanks, we have corrected it.

(92)Page 23390, lines 16-17: “High emissions of background pollutant combined with. . ...,which lead to enhance water uptake ability of summicron. . .”

Response: Thanks, we have corrected it.

(93) Page 23390, lines 23-24: “. . .also play an important role in visibility degradation during the winter haze episode in Beijing.”

Response: Thanks, we have corrected it.

(94) Page 23398: “Table 1. The statistics of aerosol optical properties during observation period.”, change the “Standard derivation” to “Standard deviation”

Response: Thanks, we have corrected it in our revised manuscript.

(95) Page 23399: “Table 2. The statistics of particle number concentration during observation period.”, change the “Standard derivation” to “Standard deviation”

Response: Thanks, we have corrected it in our revised manuscript.

(96) Page 23401: “Figure 2. The three days backward trajectories of air parcels during the observation period. The colors of air trajectories represent the height during transport.”

Response: Thanks, we have corrected it.

(97) Page 23408: The Figure 9 is not analyzed or discussed in the manuscript, so delete the Figure.

Response: We have deleted the figure in our revised manuscript.

Response to David Covert (editor):

We are very grateful to the reviewer for the constructive suggestions to improve our paper. Here, all the issues raised had been addressed and our point-to-point responses to the review's comments are given below. Accordingly, the manuscript had been modified.

The discussion paper presents a comprehensive picture of this specific pollution episode in Beijing including local and regional meteorology, boundary layer depth and horizontal transport that led to the air stagnation condition associated with the episode. Concentrations of gas and particulate chemistry and size distribution are compared, analyzed and discussed.

Comments and suggestions regarding the presentation and discussion.

Figure2. The transport distances of trajectories 1 through 5 look, as an estimate, to be about 2000km. By contrast what is the average transport distance of trajectories in cluster 6?

The geographical range of cluster 6 is so limited that it is not possible to see it on the scale of the map. A magnified inset showing only cluster 6 would be useful. Such an expanded inset would fit nicely in the upper right of the overall map. Alternatively, a sentence (along with the transport distance above) stating the size of a circle or rectangle encompassing the cluster 6 trajectory path would suffice.

Response: Thanks for the suggestion. We added an expanded figure of clusters near

Beijing. Especially, the origin and transport way of cluster 6 can be seen clearly. The air parcel of cluster 6 originated from northeast area of Beijing (~250Km, Zhangjiakou City) and transport to southern of Beijing (~160 Km, Baoding city) and then transport to Beijing. The added figure has province boundaries and it is convenient to see the transport way and distance of cluster 6 compared with other clusters.

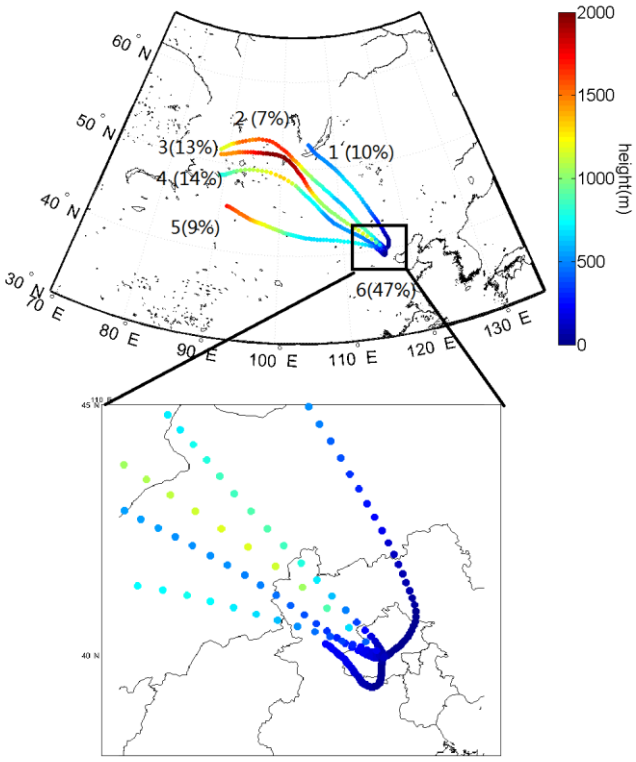


Figure 2 The three days backward trajectory of air parcels during the observation period; the colors of air trajectories represent height during transport.

Figure 3. Do the cool, blue colored soundings correspond to the time period of trajectory cluster 6? It is worth a sentence or two of discussion regarding limited horizontal motion as well as vertical mixing with respect to the limited dilution during the stagnation and pollution episode.

Response: Thanks for the suggestion. The cool and blue colored soundings correspond to soundings during30 and 31 in January. During these days, the wind comes from northern area as showed in figure S1. Therefore, the most cool and blue colored soundings is not correspond to the time period of trajectory cluster 6. We also added discussion regarding limited horizontal motion and vertical mixing with respect to the limited dilution in the revised manuscript.

Figure 5. dN/dlogDp does not serve well to illustrate the several modes you discuss. Consider adding a second panel to figure 5 showing dV/dlogDp or better, sassuming the density of 1.5 from the literature, show dm/dlogDp. The same consideration applies to figure 6 showing the modal number concentrations vs. time. A panel showing time series of modal mass concentrations would be useful.

Figures showing mass concentrations from the particle size measurements then support the following discussion of AMS mass concentrations of specific chemical species.

Response: Thanks for the suggestion. We added three figures in our revised manuscript as you suggested. Firstly, we added dv/dlogDp assuming all the particles is sphere shape. As showed in figure 5, the volume concentration mainly focused with diameters of more than 500nm and high volume concentrations occurred in nearly 800nm. Meanwhile, the volume concentrations with diameters over 1000nm increased significantly during 29. Secondarily, we added dm/dlogDp assuming a particle density of 1.5g/cm^3 in all size. As showed in figure 5, the mass concentration has the same

variation pattern with volume concentration. Finally, we added calculated mass concentration of PM2.5 according to size-resolved mass concentration of aerosol as showed in figure 6(a). We also added some interpretations regarding with those figures in our revised manuscript.

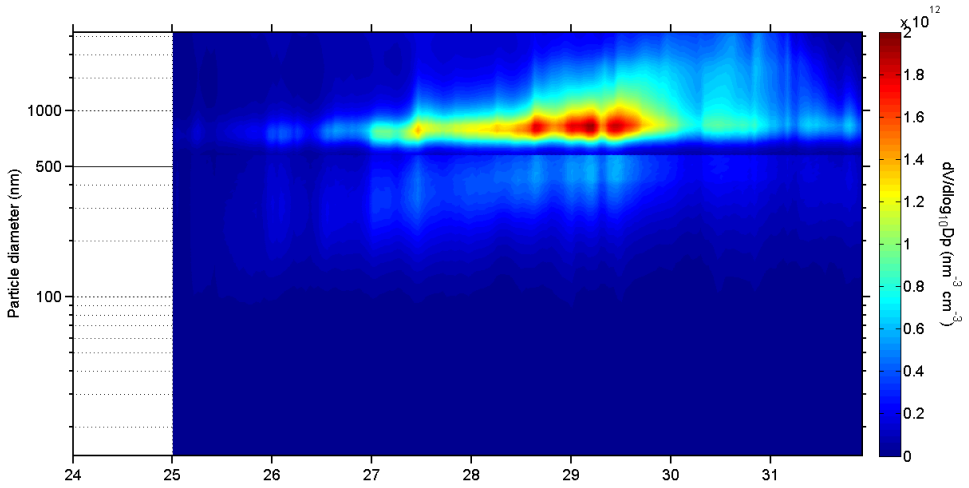


Figure 5(b) Particle volume size distribution between 14.1nm-2458nm using SMPS combined with APS from January 25 to 31.The x-axis represents the data of January and y-axis represents particle diameter (nm). The colorrepresents particle concentration (dv/dlog D_p).

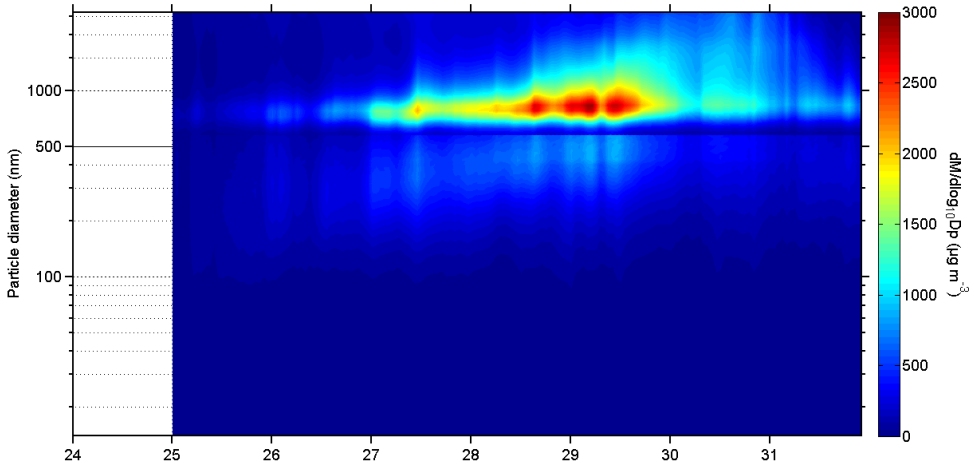


Figure 5(c) Particle mass size distribution between 14.1nm-2458nm using SMPS combined with APS from January 25 to 31.The x-axis represents the data of January and y-axis represents particle diameter (nm). The color represents particle concentration (dm/dlog D_p).

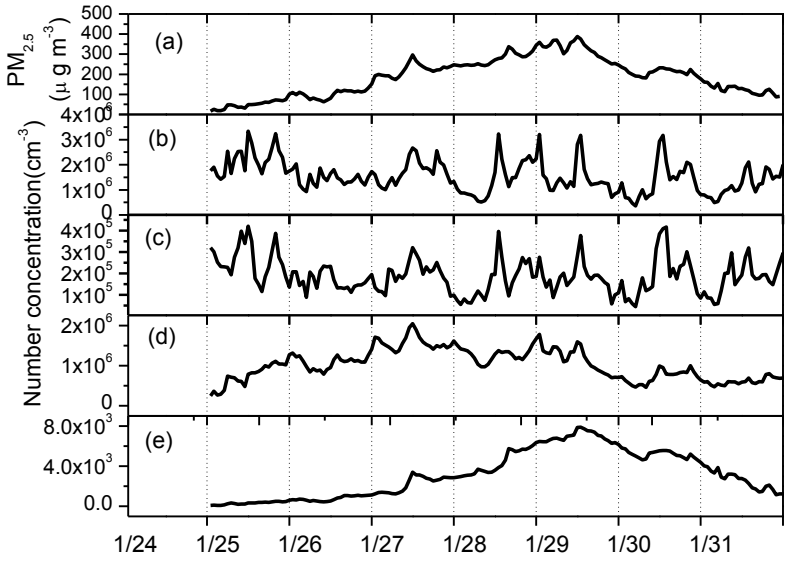


Figure 6 Time series of (a) calculated $PM_{2.5}$ mass concentration and Number concentrations of (b) nucleation mode (14.1nm-25nm), (c) Aitken mode (25nm-100nm), (d) accumulation mode (100nm-1000nm) and (e) coarse mode (1000nm-2458nm) from January 25 to January 31.

Figure S4, panel 1 would fit better with the chemical mass distributions if it were plotted as dm/dlogDp also.

Response: Thanks for the suggestion. The size resolved mass concentration showed

increased in diameter over 100nm according to calculated mass concentration data. Actually, the number concentration is increased more obviously during 28 of January. Therefore, we added the dM/dlogDp and retained the original dN/dlogDp in our revised manuscript.

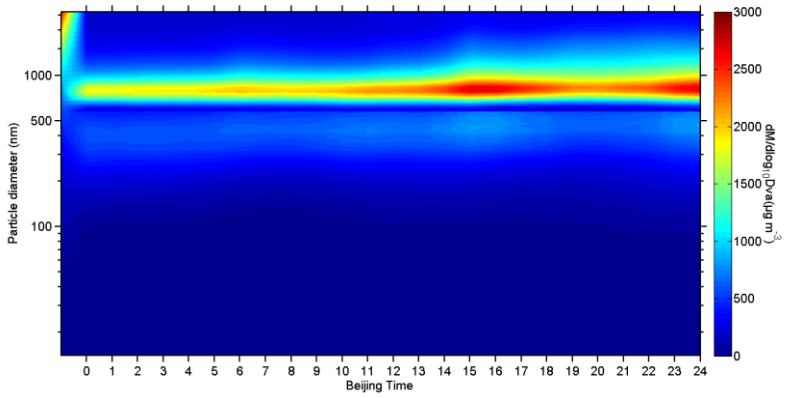


Figure S4 (b) calculated size-resolved mass concentration of particle during January 28.

Page 23384, line 25 After the coagulation process, ...There are many processes involved here, not only coagulation. Some mention of dilution should be made. As is often the case it is meteorology can drive major changes in pollution levels, gas and particulate parameters. Its hard to tease out the aerosol dynamics processes alone.

Response: We agree with you. We also added some explanations in our revised manuscript.

Page 23385 line 4 Chemical compositions, mass fractions, O:C ratio and m/z 44 of NR-PM1 are presented in Fig. 7a–c. A brief discussion of the importance of m/z 44 in the AMS spectra and how it relates to organic particulate compounds would be useful for the general reader. Also, this would support your discussion of SOA on the next page.

Response: Thanks for the suggestion. The m/z 44 is the signal of secondary organic aerosol (SOA) from aerosol mass spectrometer. The more is abundance, the more SOA fraction in organic aerosol. We added the discussion of the importance of m/z 44 in the AMS spectra in our revised manuscript.

Section 3.6.1

I do not understand something in this section that is important to the discussion and your interpretation of the data.

"During the measurement period, the atmosphere was stable with low wind speed (2.5ms−1). We calculated the aerosol scattering hygroscopic growth factor with elevated relative humidity and fitted the scattering growth curve as shown in Fig. 11. The RH was divided into eight bins, and the average scattering coefficient in each RH bin was calculated."

In the methods section you say: "An integrating nephelometer (Model 3563, TSI Inc., Minnesota, USA) was used to measure the total light scattering and hemispheric back scattering coefficients (for angles between 7–170, respectively) of **low RH aerosol** at wavelengths of 450, 550 and 700 nm, no size-selective inlets were used." What was average value of the "low RH" in the neph? Was is controlled in any way? Are the RH values discussed here and shown in figure 11 the RH in the nephelometer or are they ambient RH? Were the calculated f(RH) values of the ambient aerosol based on the Improve model, eqn. 6 rather than the nephelometer measurements? If, in fact, the light scattering measurements were made by the nephelometer where its sensing

volume was at low RH, and the fit is light scattering vs. ambient RH, then what is shown is not actually f(RH) but the relation of ambient RH to the scattering efficiency or size distribution of the aerosol resulting from rapid atmospheric ageing via processes such as gas to particle conversion, coagulation, uptake of gases by highly hydrated particles, etc.

Response: Thanks for the comments. Firstly, the RH data in the neph is not very precisely, because its sensor is not calibrated before the campaign. It just measure a relative dry atmosphere in the chamber compared with that in the ambient due to the heating in the neph. In our original manuscript, we want to apportion light scattering using IMPROVE method. However, we did not have f(RH) curve during episode and we regard light scattering coefficients vs ambient RH as light scattering hygroscopic grow in different relative humidity. The RH discussed in the original manuscript is ambient RH measured by meteorology station. In our revised manuscript, we deleted 3.6.1 part and we used f(RH) curve during polluted conditions obtained in Northern China Plain (Wuqing) in January by (Chen et al., 2014). The f(RH) curves used are given below.

$$\mathrm{f}(RH) = 1.03 * (1 - RH)^{-0.26 * RH} \quad RH < 60\%;$$
$$\mathrm{f}(RH) = 1.14 * (1 - RH)^{-0.25 * RH} \quad RH > 60\%;$$

Using this f(RH) curve and chemical components of organic, sulfate (ammonium sulfate and ammonium bisulfate), ammonium nitrate and ammonium chloride and

multiple linear regress method, we can get light scattering coefficient of each chemical components.

It should be addressed here that we added ammonium bisulfate to light scattering apportionment. For the whole observation period, the average mass concentration of ammonium, sulfate and nitrate is 17.4μg m^{-3} (~1 mole), 37.2 μg m^{-3} (0.39 mole) and 28.4μg m^{-3} (0.46 mole). To neutralize sulfate and nitrate, total amount of ammonium is still need (0.39*2+0.46>1). Aerosol particle is acidity and ammonium bisulfate and liquid sulfuric acid exist in aerosol particle. Based on this, we added bisulfate into our calculation. The results are showed in figure 12 and 13, organic components still is dominated for light scattering and the fraction of sulfate increased due to its mass fraction. we also revised this part in our manuscript.

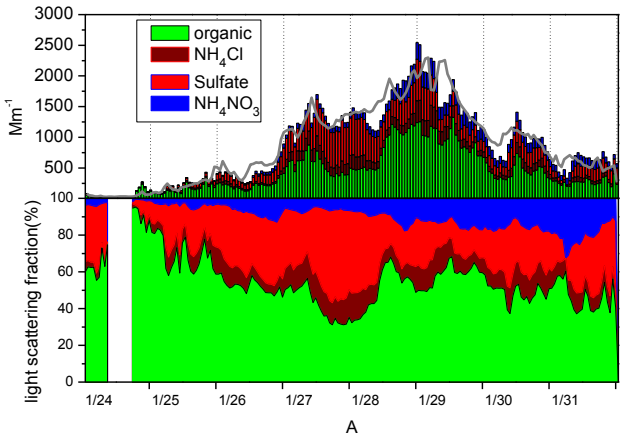


Figure 12 Time series of (a) apportioned light scattering coefficients of each aerosol components compared with measured (b) light scattering fractions of each aerosol components.

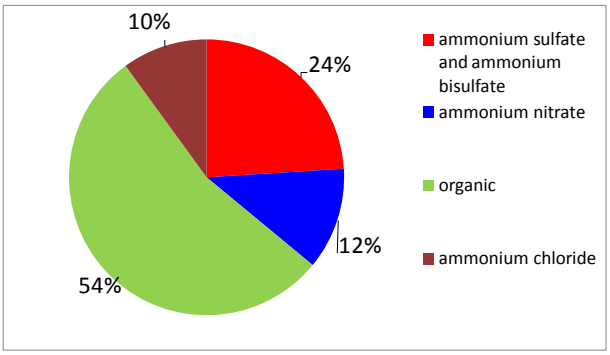


Figure 13 Averaged light scattering contribution of each aerosol components during the haze episode

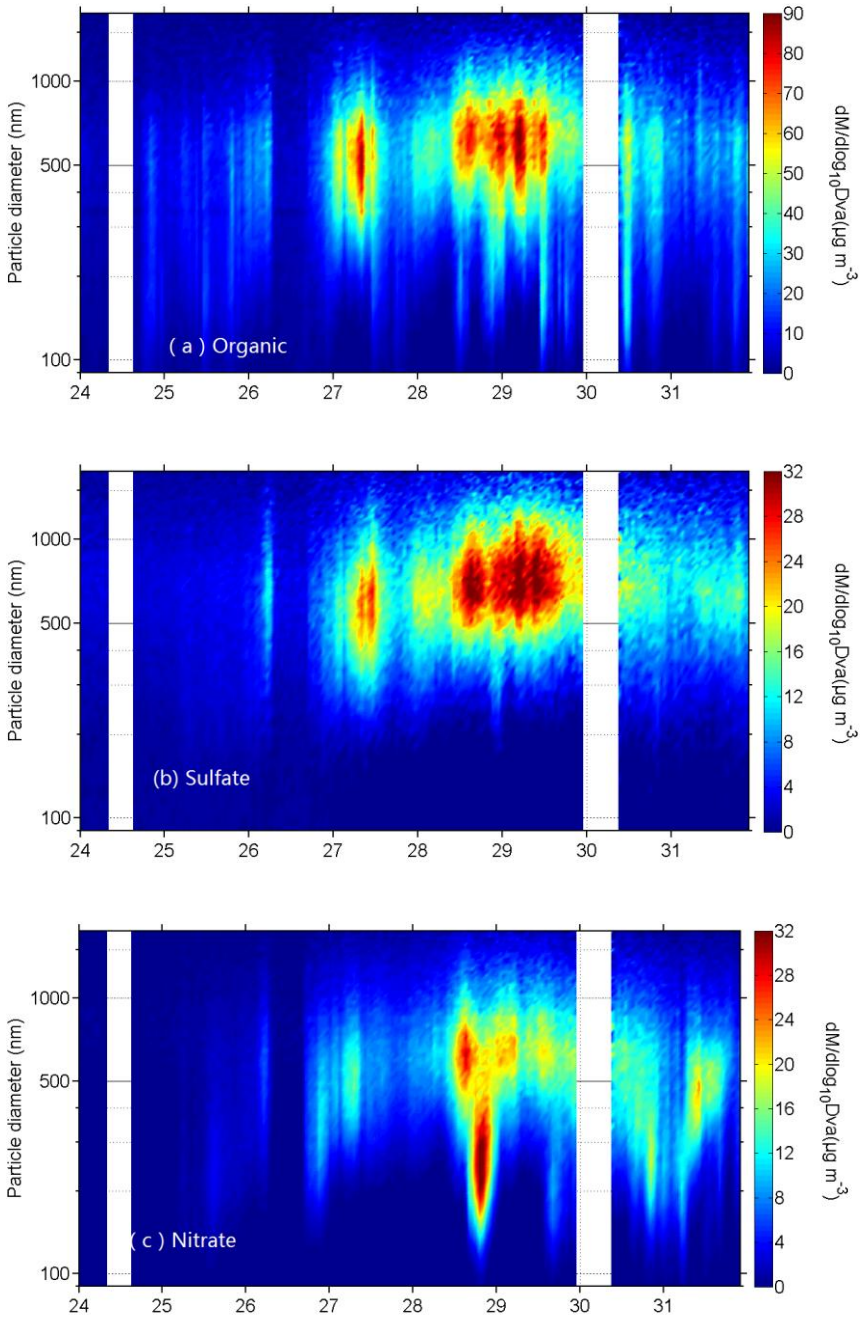
The RH at the surface, figure S1, is in the range 60 to 80% during the latter period of the episode. Given the lapse rate in the boundary layer, the RH at the top of the boundary layer must be 100%. Was the boundary layer cloud topped? What was the average boundary layer RH? The boundary layer RH is important for hygroscopic growth, liquid water content of the aerosol and water uptake of soluble gaseous pollutants. Its also important for slant range visibility which impacts aircraft operation and safety.

Response: Thanks for the comments and we agree with you. The average boundary layer RH observed from surface measurements is nearly 62% for the whole period and it reaches 80% during latter observation period (average of 28, 29, 30 and 31). We think cloud amount is limited and it is hard to recognize aerosol or cloud during extensive haze episodes like this either from space or in-situ measurements.

Correction

In our original manuscript of figure 8 and figure S4, we mistaken size-resolved data of sulfate and nitrate due to its similar mass concentration. Here, we corrected this and

the associated interpretations have also been change in our revised manuscript.



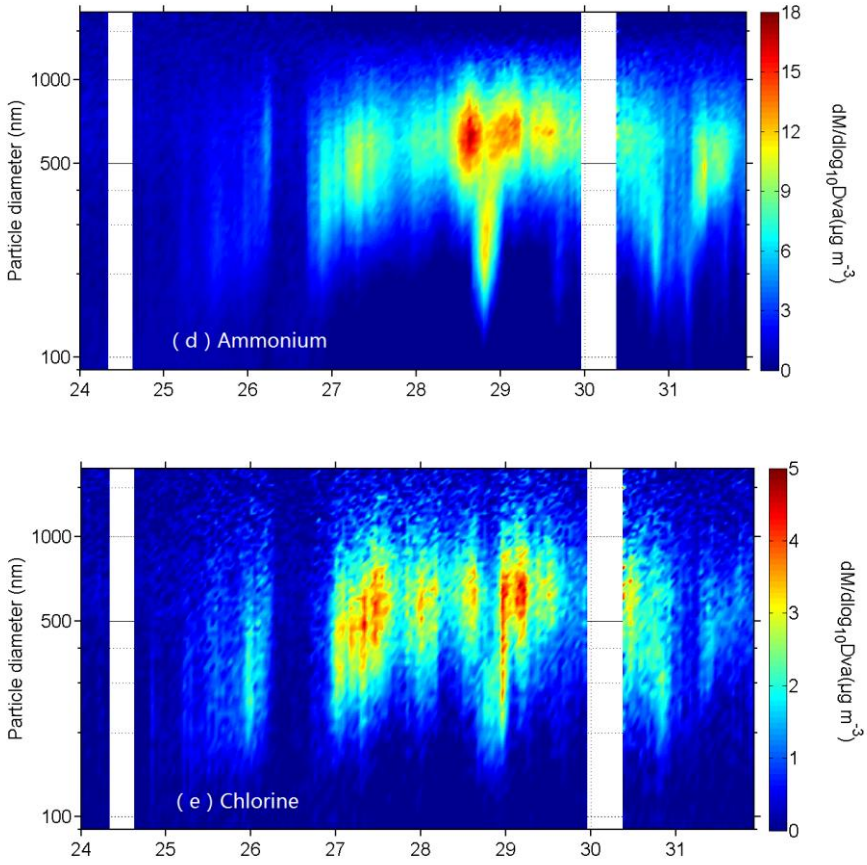


Figure 8 Size-resolved chemical compositions of (a) organic (b) sulfate (c) nitrate (d) ammonium and (e) chlorine

Chen, J., Zhao, C.S., Ma, N. and Yan, P., 2014. Aerosol hygroscopicity parameter derived from the light scattering enhancement factor measurements in the North China Plain. Atmos. Chem. Phys., 14(15): 8105-8118.

Liu, Z. et al., 2015. Seasonal and diurnal variation in particulate matter (PM10 and PM2.5) at an urban site of Beijing: analyses from a 9-year study. Environmental Science and Pollution Research, 22(1): 627-642.