Dear editors,

There is a response to reviews of our manuscript “Insights into a historic severe haze weather in Shanghai: synoptic situation, boundary layer and pollutants” (acp-2015-665). We thank very much for anonymous reviewers, and their suggestions are helpful for improving our manuscript. According to reviewer’s suggestions, we make revision to the manuscript in detail, all of revision have been marked in red in the new manuscript. The following is a point-to-point answer to comments.

For Referee 2

Question 1: In the abstract, Correlation between visibility and water soluble ion. Looking at the **Fig. 13** it is difficult to judge whether the low correlation is outcome to selection of wrong function to fit? If that is not the case authors may explain in manuscript.

Answer: In the section which tells the correlation between visibility and water soluble ions, it’s not linear relationship between two individual parameters. According to a preliminary analysis of these data, we choose to run nonlinear regression correlation analysis and the fitted curves can be obtained through using the exponential function：$y = ax^b$.We just wanted to study if the single water-soluble ions, not only high ambient RH in large, can directly influence the atmospheric visibility to some extent.

Question 2-8, 13, 21:

Answer: We have specified them respectively using highlight of red in our revised manuscript. And the corrected parts are shown in line 54, 66, 73, 159, 161, 166, 171, 175~185, 270~273, 290 in our new manuscript.

Question 9: In section 2.2, as in previous comment, He et al. (2006) have not discussed errors of overlap correction instead they have cited Welton et al. (2002). Moreover the overlap error is instrument specific and the value 10% reported by Welton et al. (2002) may or may not applicable to system used in this study. Authors should provide their own analysis of error though they may use approach taken by Welton et al. (2002) for determining the error.

Answer: Although we are not discuss errors of overlap correction, but in practice it has been calibrated in this approach taken by Welton et al. (Welton E.J., Voss K.J., Quinn P. K., Flatau P. J., Markowicz K., Campbell J. R., Spinhirne J.D., Gordon H.R., Johnson, J. E., Measurements of aerosol vertical profiles and optical properties during INDOEX 1999 using micropulse lidars, J. Journal of Geophysical Research: Atmospheres, 107, doi: 10.1029/2000JD000038, 2002).

Question 10: In section 2.2: What method was used to control relative humidity in nephelometer. If it was using heated inlet it will reduce volatile and semi-volatile aerosols.

Answer: In order to control relative humidity below 60%, our lab choose to use a silica gel type diffusion drier before the ambient aerosol entering nephelometer. The temperature inside the drier keeps pace with ambient atmosphere. Therefore, it’s no need to worry the reduction of volatile and semi-volatile aerosols by using heated inlet instead.

Question 11: In section 2.2: Since the visibility data are discussed in more details later on it will be appropriate if authors provide more details on visibility measurements like what type of sensor was used, what was accuracy and if there were specific data filtering, analysis etc. applied to visibility measurements?

Answer: The Visibility sensor (Belford, M6000) is an instrument used to measure the visibility with

a compact, high performance. Visibility is detected using widely accepted principles of forward scattering. A high output infrared LED transmitter projects light into a sample volume, and light scattered in a forward direction is collected by the receiver. The light source is modulated to provide excellent rejection of background noise and natural variations in background light intensity. The absolute accuracy of the Belfort Instrument Model 6000 is a result of the accuracy of Belfort visibility calibration standards. According to the visibility range（20 ft. to 50 miles），the accuracy of the instrument is 10 ft. (±10%). The data of the instrument was measured at 5 minutes time resolution. Moreover, periodically inspecting the sensor for dirt or other obstructions and carefully cleaning the protective glass windows in the Receiver and Transmitter is particularly necessary for valid measurements. We have added this description in section2.2 in our revised manuscript.

Question 12: It is authors' assumption that severe haze event might have caused health problem. Either authors should state it as assumption or cite study that has assessed impact of haze on health.

Answer: We have put our citations which had assessed impact of haze on health into our manuscript. Cao et al. (Cao J, Xu H, Xu Q, et al. Fine particulate matter constituents and cardiopulmonary mortality in a heavily polluted Chinese city, J. Environmental health perspectives, 120, 373-378, 2012) observed that PM2.5 contained with the combustion of fossil fuel had great possibility of an appreciable influence on the health effects in Xi'an.

Question 14: **In section 3.1.5**: Were BC concentration or absorption coefficient estimates corrected for shadowing effect?

Answer: The attenuation cross-sections of other substances like hematite and certain organics such as aromatics rise significantly with decreasing wavelength in the near ultraviolet or even in the visible region. This fact is why most soil and rural airborne dust samples have a brownish color. The presence of strong UV absorption is an indicator for the presence of Fe2O3 or some organic compounds (Weingartner et al., 2003, Absorption of light by soot particles: determination of the absorption coefficient by means of aethalometers, Journal of Aerosol Science, 34, 1445-1463). Other sources of uncertainty in BC mass concentrations using an Aethalometer arise from instrumental noise, flow rate, filter spot area and detector response. Taking into account all these effects and the variations in attenuation cross-sections, the overall uncertainty in the reported BC mass concentrations is estimated to be within ±10%. Black carbon measured using optical absorption method is often equated to EC in terms of the physicochemical properties such as thermal stability and high light absorption. However, it is possible for some organic components of the ambient aerosol to contribute to the absorptivity of the PM. Adsorption coefficients have been observed to be different on various locations and for different chemical physical mixture of aerosols (Jeong et al., 2004, Measurement of real-time PM2.5 mass, sulfate, and carbonaceous aerosols at the multiple monitoring sites, Atmospheric Environment, 38, 5247-5256). Before the campaign of our studies, the attenuation cross section used in the Aethalometer was adjusted to get the greatest accuracy required for site using the method of the comparison between the Aethalometer BC data and the thermal optical analysis EC data described in detail by our other article (Cheng et al. 2010). We have corrected the raw data as far as possible, including shadowing effect.

Question 15: **In section 3.1.5:** Value of alpha (mass absorption efficiency) turns out to be 8.28m^2/g for 6th Dec. but 7m^2/g for clean period based on the values provided in the brackets.

Answer: We adopt BC absorption efficiency as 8.28 m2/g to calculate aerosol light absorption coefficient with every values. As it illustrates above, this period of time is classified into haze and clear days. The following analysis show the average values of Ab in the clean periods, which were calculated with BC before. In our opinions, we think it's no need to calculate backward using the mean values.

Question 16: **In section 3.1.5:** Absorption coefficient, scattering coefficient and extinction coefficients are function of wavelengths. At what wavelength extinction coefficient was calculated?

Answer: As it's mentioned above in section 2.2 "Aerosol scattering coefficients (525 nm) were measured using an Aurora-1000 nephelometer (Ecotech Pty Ltd., Australia) at 5 min resolution", the three coefficients are all calculated at 525 nm wavelength.

Question 17: **In section 3.1.6:** Authors attribute two peaks in diurnal pattern of number concentration to rush hour traffic. 7th December was Sunday. (Assuming Sunday is holiday in Shanghai) Why is 7th December peaks are not any different from previous days (in fact they are higher than later days) if these peaks are due to rush hour? In fact the statement is contradictory statement to your discussion about effect of boundary layer dynamics on concentration.

Answer: Although Sunday is holiday in Shanghai, there are still rush hours of traffic and two peak pattern because of a very large amount of vehicles and motors (more than 3 millions). Other factors, such as meteorological conditions, e.g. low wind speed and high RH, contribute to pollutant pooling because of bad atmospheric diffusion. On weekend (7^{th} Dec.), higher ambient RH, lower temperature and lower wind speed resulted in low boundary layer and relatively stable nature. We discussed the influence of meteorological factors and RH on pollution formation in the follow sections.

Question 18: **In section 3.1.6:** Authors state that number size distribution is wide during hazy episodes. Authors may consider including analysis on whether this observation consistent with hygroscopic growth of the particles.

Answer: We make great efforts to obtain the number size distribution of particles. To avoid that particles packed with water by the property of hygroscopic growth were detected as bigger improperly, the silica gel diffusion drier was installed before almost every instruments controlling the relative humidity of ambient aerosol. So we can simply believe that the machines monitor the real sizes of dry particles.

Question 19: **In section 3.1.6:** In discussion of CCN, authors may consider discussing what fraction of N is CCN and whether that fraction changes between hazy and clear days?

Answer: For the important role of CCN in the population of atmospheric aerosol, we must understand the source, properties, impact factors and their evolution. So we paid great attention on discussing what fraction of condensation nuclei is CCN and whether that fraction changes between hazy and clear days.

Question 20: **In section 3.1.7:** conclusion drawn in this section about vehicular vs stationary sources based on ratio of nitrate to sulphate ion is not included in conclusion section as well as in abstract!

Answer: we have already added the conclusion in conclusion section and in abstract in highlight.

Question 22: **In section 3.2.4:** Authors state that during Haze (which is also a period of high pollution) kappa values are high but during clear day kappa values are low. Also the kappa value reported in this study are substantially lower than values reported for Beijing by Gunthe et al.

(2011).

Answer: We have downloaded and carefully read the paper you supplied. Both of us reported the effective hygroscopicity parameters (κ), and noticed that the parameter can be calculated as a function based organic and inorganic mass fractions (f_{org}, fi_{norg}). Gunthe et al. (2011) reported decrease in kappa value with increase in pollution, it is really contrast to our result. But Kappa is calculated along with the data of chemical compositions. When larger proportion of mass fractions during the pollution is organic compounds, it will meet smaller values of Kappa. The parameter does not directly related to the occurrence of pollution. That is to say the hygroscopicity parameter (kappa) depends on chemical compositions and their amounts.

Question 23: **In section 3.2.4:** For a correlation analysis to be useful, authors should report more details on how did they arrived on choice of functions for fitting, what were significance test done?

Answer: The similar answer can be found in question 1.

Question 24: **Fig. 1**: In spite of low PM2.5 and PM10 on 8th December (and 4th Dec. morning) visibility is low. Authors may elaborate on it in the manuscript.

Answer: Based on the general meteorological conditions (e.g., wind speed, wind direction, RH and temperature) on 8th Dec. and 4th Dec. morning, higher ambient RH, lower temperature and lower wind speed may determine the phenomenon of this kind. Even the concentrations of PM2.5 and PM10 were low, we have one part to analysis the potential contribution of BC and ambient RH to atmospheric visibility impairment. According to the result, it is reasonable to some extent that low PM2.5 and PM10 exist with the low visibility. We have added more manuscript about it.

Question 25: **Fig. 7**: CO concentration in range of 1 to 3μg/m^3 are extremely low values. For example Gao et al. (2005) have reported CO values of the order of several hundred μg/m3 at Mt. Tai. I expect CO concentration in Shanghai higher than Mt. Tai.

Answer: We have specified them in new figure 7 in our revised manuscript. The figure shows as below.

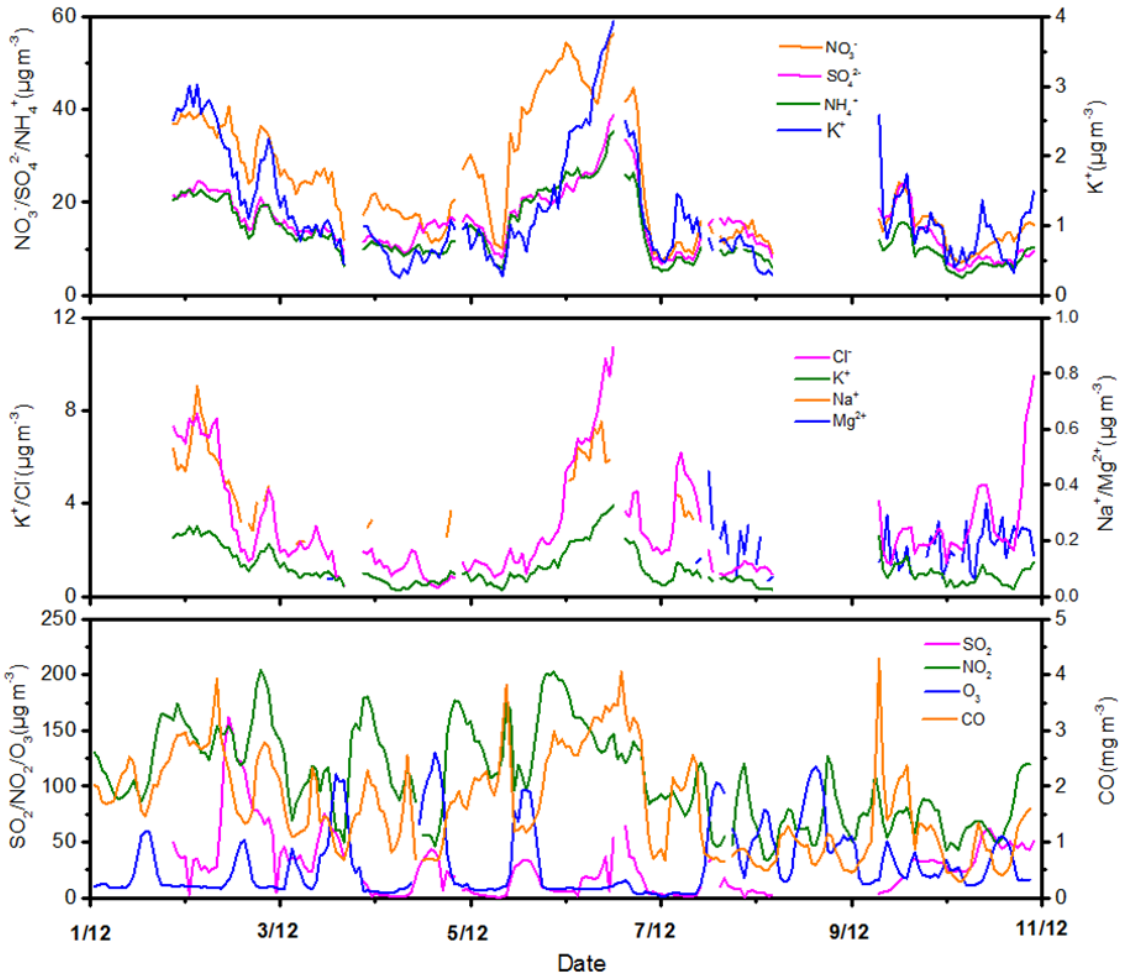

Figure 7: Temporal variations of chemical species in particles from 1 to 10 December.

Technical Comments

Question 1-3, 5-6 and 8-10

Answer: We have read the manuscript vary carefully and corrected any places having grammar errors or mistakes, which are highlighted in red in the revised manuscript.

Question 4: Page 32565 Line 18: "... Shanghai based on online water ..." What is meaning of online here?

Answer: We use MARGA to monitor aerosol and gases at 1h time resolution, which may much higher than other chemical analyzers. So, the meaning of online can be likely to be expressed as synchronous or simultaneous.

Question 7: Page 32573 Line 2: What is meaning of word "integrating" here. Appears to me confusing along with word "size-resolved" used in the same sentence.

Answer: We use the instrument WPS-1000 XP to obtain a time series of aerosol size spectra. It separates polydisperse aerosol particles by size for high-resolution measurements of particle-size distribution. So, I mean the word “size-resolved” here equals to “particle-size distribution”, and the word “integrating” equals to “having integrals by using number concentrations of particle-size distribution”.

Thanks very much!

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