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Title: "Measurement report: Chemical characteristics of PM2.5 during typical biomass burning season at an agricultural site of the North China Plain"

Anonymous Referee #3

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This is a well-written and structured manuscript to discuss the biomass burning pollution status in rural atmosphere of North China by presenting the biomass burning tracers and secondary inorganic ions in $PM_{2.5}$ during a transition heating season. It is interesting that an episode with extreme biomass burning tracer levels was identified to present the severity of biomass burning pollutions. Biomass burning tracer ratios were also introduced to discuss the biomass source types and burning process. I agree with the data discussion and to publish on ACP. There are some minor errors are necessary to be revised before publishing.

Our reply: We thank the reviewer for his/her valuable comments. We have prepared the point-by-point responses to address the reviewer's comments as shown below. The blue color texts indicate the amended sections in the manuscript. The line numbers correspond to those in the revised version of the manuscript.

Specific comments:

(1) Line 103: Are the "6 whole-day samples" are used in the data analysis? Please make a note for the "Whole period, N=37" in table 1 to explain sample categories in the data analysis.

Our reply: According to the referee's comment, we have added a note for "Whole period, N=37" in table 1, explaining sample categories in the data analysis.

"Six whole-day samples were included in the data analysis of the "Whole period". (See Line 649)

(2) Line 153: Why $PM_{2.5}$ measured (measured with High volume sampler) data was not used instead of $PM_{2.5\text{-}cal}$?

Our reply: $PM_{2.5}$ samples were collected using a high-volume sampler (Thermo Scientific, MA, USA; the flow rate was 1.13 m^3 min^{-1}). Quartz fiber filters (8×10 inch, 2500 QAT-UP; Pall Corporation, NY, USA) taken from the same lot were used for the entire sampling campaign. It is difficult to weigh those big filters with typical laboratory balances; thus, there were no measured $PM_{2.5}$ concentration obtained in this study. Actually, the reconstituted $PM_{2.5\text{-cal}}$ mass concentration method has been commonly applied by other filed observations, to demonstrate the variation of ambient $PM_{2.5}$ pollution level (Turpin and Lim, 2001;Kanakidou et al., 2005;Cheng et al., 2015).

(3) Line 163: Organic matter (OM) appears first time in the paper to show the OM contribution to $PM_{2.5\text{-cal}}$. I suggest to explain that how OM was calculated.

Our reply: We thank the referee for this valuable comment. We added the definition of OM in the revised manuscript.

"Organic matter (OM), calculated by multiplying OC values with a coefficient of 1.6, was the most abundant PM component, the daily average value of which was 70.4 ± 49.6 μg m^{-3}, …" (See Lines 167-169)

(4) Line 170: Please show the data range in these references during summer and winter seasons to give a better understanding how high levels the anhydrosugars were.

Our reply: According to the referee's suggestion, we added the data range of levoglucosan during summer and winter season observed in Beijing in the reference.

"The ambient concentrations of levoglucosan in this study were higher than those observed in the city of Beijing during the summer (averaged at 0.23 ± 0.37 μg m^{-3}, in the range of 0.06 to 2.30 μg m^{-3}) and winter (averaged at 0.59 ± 0.42 μg m^{-3}, in the range of 0.06 to 1.94 μg m^{-3}) of 2010-2011 (Cheng et al., 2013)." (See Lines 173-176)

(5) Line 199: The contribution of LG to $PM_{2.5\text{-cal}}$ during daytime in Figure 3 was 0.45%. Please check the data.

Our reply: We thank the referee for this valuable comment. We checked the data and confirmed

that the contribution of levoglucosan to $PM_{2.5\text{-}cal}$ during daytime was 0.45% and corrected it in the revised manuscript.

"Consequently, the contribution of levoglucosan to $PM_{2.5\text{-}cal}$ during daytime (0.45%) was observed to be considerably lower than that during nighttime (0.64%) (Figure 3)." (See Lines 204-206)

(6) Line 202: Please insert references for the photochemical formation of secondary inorganic species.

Our reply: According to the referee's suggestion, we added the related references for the photochemical formation of secondary inorganic species in the revised manuscript.

"Thus, the secondary inorganic species (SO_4^{2-}, NO_3^- and NH_4^+) were enhanced during daytime due to photochemical formation (Sun et al., 2013; Zheng et al., 2015; Wu et al., 2018)." (See Lines 207-209)

(7) Line 234: In Table 2, the OC contribution during intensive BB period II was 96.3, but not 59.9. Please check the data.

Our reply: We thank the referee for this valuable comment. We checked the data and confirmed that the OC concentration during the intensive BB period II was 96.3 μg m^{-3}, and corrected it in the revised manuscript.

"The concentrations of OC and EC were also observed to be strongly elevated in period II (Table 2), and especially OC levels increased to 96.3 μg m^{-3} during the intensive BB episode II, nearly 6 times of those during the minor BB period (16.2 ± 7.52 μg m^{-3})." (See Lines 252-254)

(8) Line 276: Please insert the increasing range of OC fraction.

Our reply: According to the referee's comment, we added the increasing range of the OC fraction in the revised paper.

"…, while the OC fraction increased significantly from 34.0% during the minor BB period I to 65.4% during the intense BB period II." (See Lines 299-300)

(9) Line 286: Check the data in Figure 6, the SO_4^{2-} and NO_3- contributions during the intense BB episode were 1.93 and 7.67%.

Our reply: We thank the referee for this comment. We checked the data and confirmed that the contributions of SO_4^{2-} and NO_3^- to $PM_{2.5\text{-cal}}$ during the intense BB episode were 1.93% and 7.67%, respectively, and corrected them in the revised manuscript.

"The contributions of SO_4^{2-}, NO_3^- and NH_4^+ to $PM_{2.5\text{-cal}}$ during the minor BB episode (11.6%, 20.5% and 12.5%) substantially declined during the intense BB episode (1.93%, 7.67% and 4.24%)." (See Lines 308-310)

(10) Line 295: The range of LG/MN ratios from crop residue burning in source emission studies is helpful to understand the biomass types.

Our reply: According to the referee's comment, we added the findings regarding levoglucosan/mannosan ratios from different biomass burning source emission studies in the revised paper.

"Based on source emission studies, the levoglucosan/mannosan ratios from crop residue burning, i.e., rice straw, wheat straw and corn straw, are similar and are characterized by high values (averaged at 29, in the range of 12 to 55) (Zhang et al., 2007; Engling et al., 2009; Cheng et al., 2013; Jung et al., 2014), yet overlapping with those from hardwood (averaged at 28, in the range of 11 to 146) (Bari et al., 2009; Jung et al., 2014) and grass burning (18.2 ± 10.2) (Sullivan et al., 2008), while softwood is characterized by relatively lower levoglucosan/mannosan ratios (averaged at 4.3, in the range of 2.5 to 4.7) (Engling et al., 2006; Cheng et al., 2013; Jung et al., 2014)." (See Lines 320-327)

(11) Line 304: The LG/K^+ ratio during III in Table 2 was 0.51, please check the data.

Our reply: We thank the referee for this comment. We checked the data and confirmed that the levoglucosan/K^+ ratio during episode III was 0.51, and corrected it in the revised manuscript.

"The levoglucosan/K^+ ratios during periods III and IV (0.51 and 0.53) were similar to those during a BB episode at an urban site in Beijing during wintertime (levoglucosan/K^+ = 0.51) (Cheng et al., 2013)." (See Lines 335-337)

Reference:

Cheng, Y., He, K.-b., Du, Z.-y., Zheng, M., Duan, F.-k., and Ma, Y.-l.: Humidity plays an important role in the PM2.5 pollution in Beijing, Environmental Pollution, 197, 68-75, 10.1016/j.envpol.2014.11.028, 2015.

Kanakidou, M., Seinfeld, J., Pandis, S., Barnes, I., Dentener, F., Facchini, M., Dingenen, R. V., Ervens, B., Nenes, A., and Nielsen, C.: Organic aerosol and global climate modelling: a review, Atmospheric Chemistry and Physics, 5, 1053-1123, 2005.

Turpin, B. J., and Lim, H.-J.: Species Contributions to PM2.5 Mass Concentrations: Revisiting Common Assumptions for Estimating Organic Mass, Aerosol Science and Technology, 35, 602-610, 10.1080/02786820119445, 2001.