Anonymous Referee #1

This manuscript presents the results of an intensive field campaign of two week duration in an area south of Beijing. The manuscript focuses on the study of the effect of aerosol hygroscopicity in the aerosol light scattering coefficient. Despite the short measurement period, the data collected are interesting and the results are of scientific significance. Nevertheless, I have some minor comments that need to be clarify by the authors.

Line 78: Briefly describe the humidifying scheme by Carrico et al. (1998)
Reply: The humidifying scheme by Carrico et al. (1998) is described in the manuscript as: "The water vapor controlled by the temperature of the liquid water in the outer annulus of the tube passes through a Teflon membrane, humidifying aerosols in the inner tube (Carrico et al., 1998). The temperature of the liquid water was controlled by adjusting the power of the water baths."
[Lines 84-86]

Line 80: Was the tandem nephelometer calibrated with ammonium sulphate or other salt of known hygroscopicity? This is highly recommended to assure that the system is functioning correctly and that the RH inside the nephelometer chamber is correct (see Burgos et al. (2019) and Fierz-Schmidhauser et al. 2010b).
Reply: The tandem nephelometer in this study was calibrated with ammonium sulphate, whose deliquescence relative humidity (DRH) was 79.9±0.5% at 298 K. The DRH of pure ammonium sulfate aerosols generated in the laboratory was 80.367%, measured by our high-resolution humidified nephelometer system (Fig. R1). This shows that the RH inside the nephelometer chamber was correct and that the system was functioning properly.
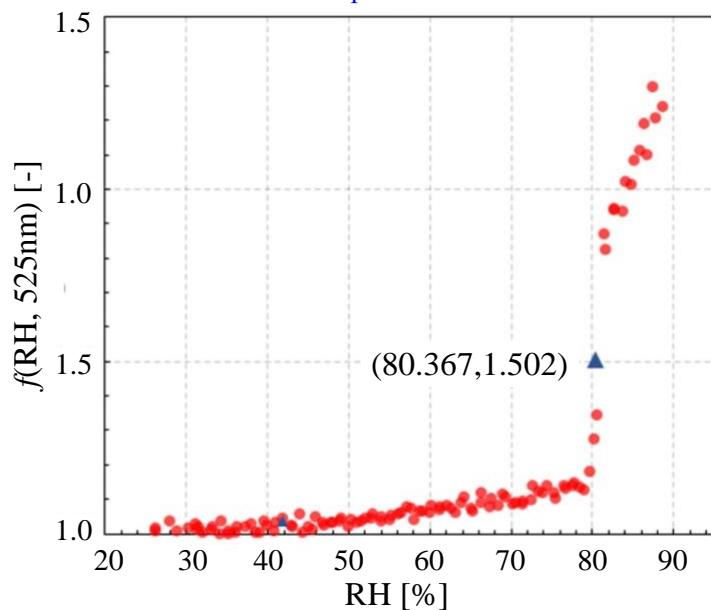

Figure R1: Deliquescence results of the pure ammonium sulfate aerosol generated in the laboratory.
[Lines 108-111]

Line 80: Were the nephelometers operated with or without the kalman filter option?
Reply: Since the RH of aerosols inside the nephelometers was constantly changing, and real measured data at every moment was needed, the nephelometers operated without the Kalman filters.
[Lines 91-92]

Line 90: The equation to calculate the dew point temperature is not the most common one. I looked in the references provided by the authors but Kuang et al. (2017) doesn't state which formula they use to calculate T dew point and the reference of Liu and Zhao (2016) is in Chinese. Please, use appropriate references for this formula.
Also, it would be interesting to see the comparison between RHin, RHoutlet and RHcalculated.

Reply: We have revised the references in the manuscript. Equations (1) and (2) are from a Ph.D. thesis in Chinese (L. Zhang, 2017), explained as follows. Because the RH levels measured by the probe built into the optical chamber of the wet nephelometer ($RH_{chamber}$) was imprecise, two calibrated RH and temperature probes were placed at the inlet and outlet of the wet nephelometer, obtaining 1-min averages of RH and temperature (Fig. R2). We used Vaisala HMP110 probes with accuracies of $\pm 0.2℃$ for the 0–40℃ temperature range and $\pm 1.5\%$ RH and $\pm 2.5\%$ RH for the 0–90% and 90–100% RH ranges, respectively. As shown in Figure R2 (b), the temperatures measured by these probes were different. However, in principle, the dew point temperatures ($T_{dew-point}$) at these positions are all the same. Since the RH and temperature probes at the outlet of the wet nephelometer (RH_{outlet} and T_{outlet}) were less affected by the humidifier, RH_{outlet} and T_{outlet} were used to calculate $T_{dew-point}$ at this position using Eq. (1):

$$T_{dew-point} = RH_{outlet}^{\frac{1}{8}}(112 + 0.9T_{outlet}) + 0.1T_{outlet} - 112. \tag{1}$$

We assume that $T_{dew-point}$ was approximately the same as that in the optical chamber of the wet nephelometer. Based on the temperature in the optical chamber ($T_{chamber}$) and $T_{dew-point}$, the actual RH in the optical chamber ($RH_{chamber}$) can be calculated by rearranging Eq. (1), i.e.,

$$RH_{chamber} = (\frac{112 - 0.1T_{chamber} + T_{dew-point}}{112 + 0.9T_{chamber}}). \tag{2}$$

[Lines 94-107]

Figures R2 (a) and (b) show time series of RH_{inlet}, RH_{outlet}, and $RH_{chamber}$ and T_{inlet}, T_{outlet}, and $T_{chamber}$, respectively. Temperatures measured by the three probes are significantly different. Since the RH and temperature probes at the inlet of the wet nephelometer is very close to the humidifying tube, T_{inlet} is influenced by the humidifier. Also, T_{outlet} is lower than $T_{chamber}$. Figure R1 (a) shows that $RH_{chamber}$ is lower than RH_{outlet}.
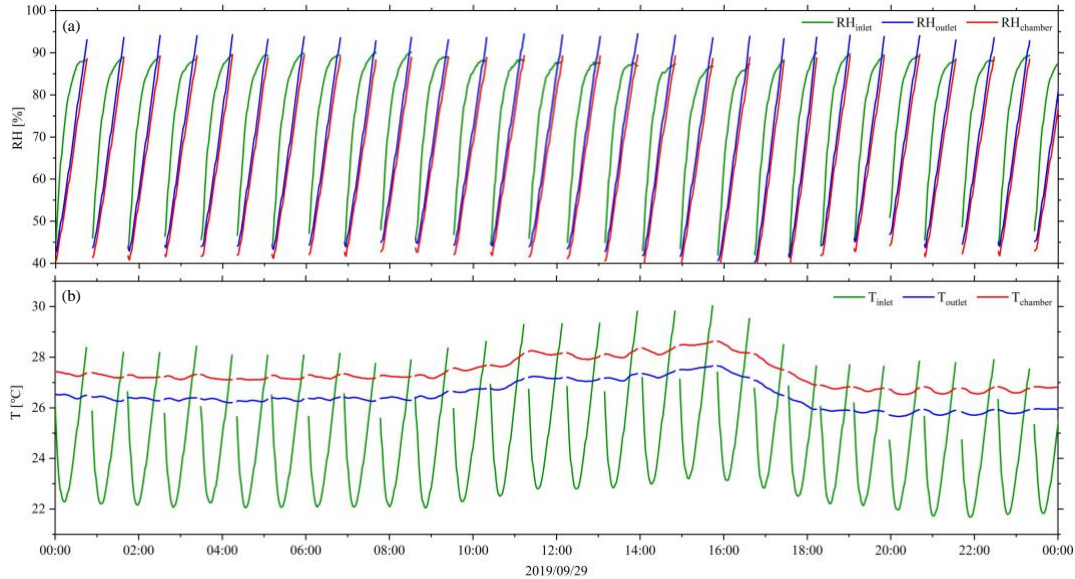

Figure R2: Time series of (a) RH_{in}, RH_{outlet}, and $RH_{chamber}$ and (b) T_{in}, T_{outlet}, and $T_{chamber}$ on 29 November 2019. Times in this figure are in the hour/minute format.
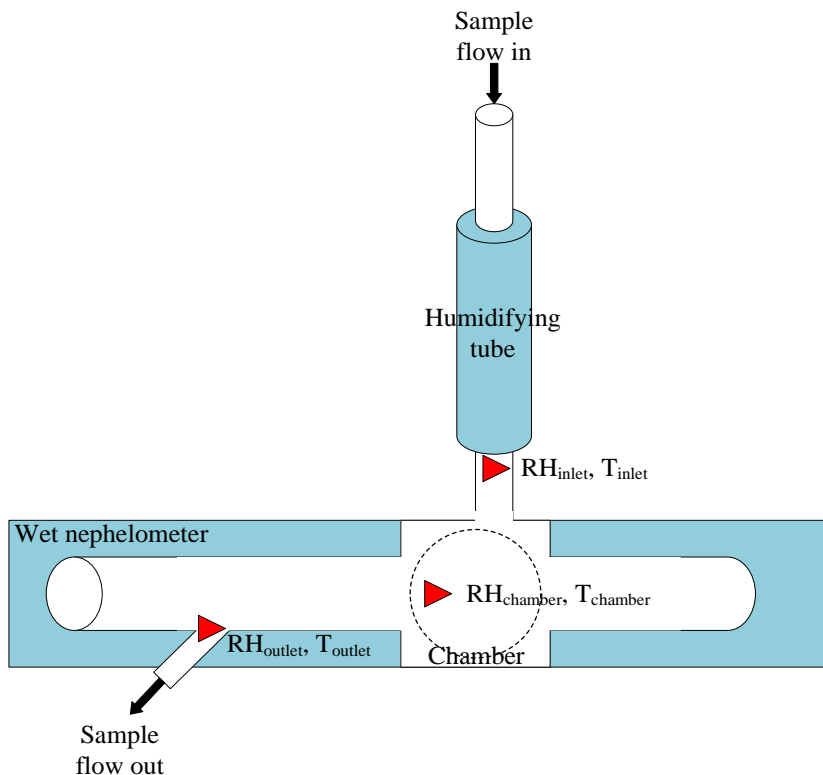
Figure R3: Diagram of the structure of the wet nephelometer. The three red triangles show the locations of the three sets of RH and temperature probes.

Line 105: I really don't understand how the f(RH) is calculated. Why f(RH) is normalized? What is the reason behind this? Also, f(RH>40%) is averaged over what? Whole dataset, each scan?
Then, in line 108 it is said that f(RH>40%) is 1. This is true for all the observations? Is it exactly 1? This calculation needs clarification.
Reply: In this study, we assumed that the aerosol is in the dry state when RH < 40%. So f(RH) should theoretically equal 1 when RH is lower than 40%. This was what was meant by the sentence: "Here, f(RH < 40%) equals 1." However, due to systematic errors and the differences in RH measured synchronously by the dry nephelometer and the wet nephelometer, respectively, measured f(RH < 40%) have small fluctuations and are not equal to 1. This is why f(RH) was normalized. Not f(RH > 40%), but the corrected coefficient (f(RH < 40%)$_{averaged}$), which was averaged over the whole dataset of RH < 40%. f(RH > 40%) was then normalized using Eq. (4).
[Lines 124-129]

Line 112: The absorption coefficient is measured at 7 wavelengths, the absorption coefficient at 520 nm is more appropriate than using the absorption coefficient at 880 nm and then convert it to 525 nm.
Reply: Done. The single-scattering albedo ($\omega_{0(525nm)}$) has also been recalculated. Also updated were Figs. 2b, 2c, 3a and Table 1.
[Lines 130-132]

Eq 6: So, only f(RH=85%) is used to calculate gamma? If the frh measurements are performed at scanning RH it can be retrieved from a potential fit using the whole RH range, which will have less errors than using a single RH point (see Zieger et al. 2010, Titos et al., 2016).
Reply: We appreciate the suggestion. Previously, only f(RH = 85%) and f(RH = 40%) were used to calculate γ, which has now been revised. The parameter γ is now retrieved from the following f(RH) parametrization scheme: f(RH) = $(1 - RH)^{-\gamma}$ (i.e., Eq. (8)), using the whole RH range (generally from ~ 40% to ~ 90%). Figures 7 and S7 have been updated accordingly.

Line 125: Include a reference to Zieger et al. 2010, who firstly introduced the hysteresis index.
Reply: The reference is added.

Eq9: Actually, what it is here called g, it is usually referred as gamma.
Reply: Thank you.

Eq. 8: The RH range used to identify deliquesce is very narrow and can miss deliquescence processes occurring at slightly different RH. Maybe consider the procedure of Zieger et al.
Reply: We appreciate the suggestion. The deliquescence observed in this study mainly resulted from the ammonium sulfate in ambient aerosols. The deliquescence RH (DRH) of pure ammonium sulfate aerosols generated in the laboratory was 80.367%, measured by our high-resolution humidified nephelometer system (Fig. S8). Forty-seven cycles of f(RH) (16% of all cycles) in this study show clear deliquescence, and the DRH of all deliquescence are mainly distributed between 78% and 80%. So the RH range used to identify deliquescence in this paper (78% < RH < 82%) does not miss deliquescent processes. In addition, if we use a larger RH to identify deliquescence, for example, 75% < RH < 85%, less data would be available to calculate $\gamma_{>85\%}$ on each hydration branch.

Fig7: Why not consider all measured species, including NH4+, Cl- and BC? Is the organic mass fraction defined differently than in Figure 6?
Reply: Since chloride ions (Cl^-) accounted for less than 1% of submicron aerosols during the entire measurement period, the influence of Cl^- on the hygroscopic enhancement factor of aerosols is essentially negligible. In addition, chemical species consisting of Cl^- are hardly determined. Therefore, the influence of Cl^- on γ has not been considered in Fig. 7. As for BC, its influence on f(RH = 85%, 525 nm) has been analyzed in Fig. 5d. Since γ is the parameter that can replace f(RH) over a wider RH range, it is not necessary to discuss the correlation between BC and γ again in Fig. 7. Considering the importance of the ammonia ion (NH_4^+) on the f(RH) of aerosols in previous studies (Zieger et al., 2010; L. Zhang et al., 2015), it is a helpful suggestion to take NH_4^+ into account. So an ion-pairing scheme was conducted to calculate the mass concentration of ammonium sulfate ($(NH_4)_2SO_4$), ammonium bisulfate (NH_4HSO_4), and ammonium nitrate (NH_4NO_3) in aerosols on the basis of the molar numbers of all ions (Gysel et al., 2007). The following is the ion-pairing scheme:

$$n_{NH_4NO_3} = n_{NO_3^-}$$
$$n_{H_2SO_4} = \max\left(0, n_{SO_4^{2-}} - n_{NH_4^+} + n_{NO_3^-}\right)$$
$$n_{NH_4HSO_4} = \min\left(2n_{SO_4^{2-}} - n_{NH_4^+} + n_{NO_3^-}, n_{NH_4^+} - n_{NO_3^-}\right) \tag{9}$$
$$n_{(NH_4)_2SO_4} = \max\left(n_{NH_4^+} - n_{NO_3^-} - n_{SO_4^{2-}}, 0\right)$$
$$n_{HNO_3} = 0,$$

where n denotes the number of moles. Figures 7a-c now show γ as a function of F_{org} (Eq. 6), where C_i represents the sum of $(NH_4)_2SO_4$ and NH_4HSO_4, NH_4NO_3, and the sum of $(NH_4)_2SO_4$, NH_4HSO_4, and NH_4NO_3 mass concentrations, respectively. Figure 7 has been revised accordingly.
The organic mass fraction defined in Fig. 7 is the same as that in Fig. 6.

Fig8: Use same color for WD from north (360º and 0º)
Reply: We have revised Fig. 8b accordingly.

Line 220: Don't understand the reasoning, which marine aerosols do the authors refer to?
Reply: The absolute values of both slopes and corresponding standard deviations (0.80±0.04 and 1.00±0.06 for f(RH = 85%, 525 nm) as a function of inorganic and organic matter mass fractions, respectively) shown in Fig. 6 were similar to those reported in Lin'an, China (0.96±0.02 and 1.20±0.04, respectively; L. Zhang et al., 2015) but much lower than those observed at Melpitz, Germany (2.2±0.078 and 3.1±0.1, respectively; Zieger et al.,

2014). This might be because the f(RH = 85%, 525 nm) measured in Melpitz, Germany, was much higher than that in Lin'an and Beijing. Ambient aerosols in Melpitz, Germany, were affected by sea salt, like sodium chloride, transported from the North Sea and highly hygroscopic. Marine aerosols have a higher hygroscopicity than aerosols influenced more by human activity.
[Lines 234-240]

Line 245: Do the authors refer to an instrument artefact due to water depletion?
Reply: Yes, we do, because the amount of water vapor passing through the Teflon membrane to humidify aerosols in the inner tube was finite at a specific temperature. The amount of water vapor may be insufficient when the proportion of inorganic matter is very high.

Line 260: It is not that in the previous studies the role of NO3- was not as important as in the present study. Quinn et al. (2005) didn't look at NO3-, their organic mass fraction was calculated using only SO42- as inorganic component. Why do the authors don't include NH4+? Previously they stated the importance of ammonia, but here it is not included. See the relationships obtained by Zieger et al. and Zhang et al.
Reply: The unclear statements have been revised. As we stated in the response to the suggestion given by the reviewer for Fig. 7, an ion-pairing scheme was conducted to calculate the mass concentrations of ammonium sulfate ($(NH_4)_2SO_4$), ammonium bisulfate (NH_4HSO_4), and ammonium nitrate (NH_4NO_3) in aerosols on the basis of the molar numbers of all ions (Gysel et al., 2007). The following is the ion-pairing scheme:

$$n_{NH_4NO_3} = n_{NO_3^-}$$
$$n_{H_2SO_4} = \max\left(0, n_{SO_4^{2-}} - n_{NH_4^+} + n_{NO_3^-}\right)$$
$$n_{NH_4HSO_4} = \min\left(2n_{SO_4^{2-}} - n_{NH_4^+} + n_{NO_3^-}, n_{NH_4^+} - n_{NO_3^-}\right) \qquad (9)$$
$$n_{(NH_4)_2SO_4} = \max\left(n_{NH_4^+} - n_{NO_3^-} - n_{SO_4^{2-}}, 0\right)$$
$$n_{HNO_3} = 0,$$

where n denotes the number of moles. The updated Figs. 7a-c show γ as a function of F_{org} (Eq. 6), where C_i represents the sum of $(NH_4)_2SO_4$ and NH_4HSO_4, NH_4NO_3, and the sum of $(NH_4)_2SO_4$, NH_4HSO_4, and NH_4NO_3 mass concentrations, respectively. Overall, γ and F_{org} are negatively correlated. The coefficient of determination between γ and F_{org} (Org/(Org+NH_4NO_3)) (Fig. 7b) was higher than that between γ and F_{org} (Org/(Org+ $(NH_4)_2SO_4$ + NH_4HSO_4)) (Fig. 7a). The coefficient of determination between γ and F_{org} (Org/(Org+$(NH_4)_2SO_4$ + NH_4HSO_4+NH_4NO_3) was the highest (Fig. 7c). This suggests that nitrate played a more significant role than sulfate in affecting aerosol hygroscopic growth during the study period in Beijing.
[Lines 273-287]

References
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