Responses to comments of referee #2

General comments:

In this manuscript a retrieval method was proposed to calculate the aerosol hygroscopicity parameter κ, based on aerosol light scattering enhancement factor f(RH) and particle number size distribution during HaCHi campaign. The CCN number concentration was estimated by using the derived κ. The method is straightforward and useful to estimate κ and to predict CCN concentration. However, several corrections and clarifications are necessary to improve the manuscript. Some discussions in the manuscript need to be better organized. The authors also need to polish the English to void colloquialism. I suggest that the manuscript may be publishable in ACP after revisions listed below.

Response: Thanks for the comments.

Specific comments:

1. In the introduction, it needs to be discussed that particle morphology can also vary considerably with atmospheric aging and RH, impacting the particle optical properties (i.e., Khalizov et al., J. Phys. Chem. 113, 1066, 2009; Pagels et al., Aerosol Sci. Tech. 43, 629, 2009). In particular, how particle morphology variation may impact their algorithm to derive κ with the f(RH) measurements.

Response: We appreciate the referee for the helpful advice. The corresponding discussion has been added into the introduction section, and the relevant references have been cited. Since the assumption of spherical particles is required for the Mie calculation, the particle morphology changes would cause uncertainty to the κ estimation with the f(RH) and PNSD measurements. We also have considered the

possible influence into the discussion on uncertainty of the derived κ in section 3.4.

2. Page 3463 Line 5-7.

Need to cite several references to discuss the particle pollution in NCP. Need to show numbers, e.g. particle concentrations.

Response: Thanks for the comment. We have added the details in the corresponding place.

3. Page 3463 Line 23-30.

It is unnecessary to describe the contents in every section. Just describe what you have done and why that's important.

Response: Thanks for the suggestion. We have revised it accordingly.

4. Page 3463 Line 23-24.

"…observation…were analyzed"

Response: Thanks. We have revised it.

5. Page 3464 Line 10-11.

Clarify the measurement period. The campaign was conducted from October to January? But the authors only showed the January data.

Response: Thanks for the comment. This work mainly focuses on the data analysis during the *f*(RH) observation period. As what we have introduced in the second paragraph of section 2, the continuous measurement of *f*(RH) was only conducted in January, but not throughout the entire HaChi winter campaign. Therefore, the

observations obtained in January were used here. To make it clearer, we have added the sentence below to clarify the motivation of this study.

"This work mainly focuses on the method of deriving κ from the measured f(RH) in January in the northern part of the NCP region."

6. Page 3465 Line 20.

If possible, show the inter-comparison at high RH. As in the discussion afterwards, the CCN comparisons are different at low RH and high RH.

Response: We only have one nephelometer to measure the σ_{sc} under humidified conditions, while the other one operated in parallel is just used to measure the dry σ_{sc}. Thus, the inter-comparison of σ_{sc} at high RH is not available.

As for the different comparison results of N_{CCN} at low supersaturations and high supersaturations, the possible reasons can be concluded briefly as follows. Uncertainties induced by both of the measurement (such as PNSD, σ_{sc}, RH, and N_{CCN}) and calculation (e.g., assumptions applied in the calculation of κ and N_{CCN}) errors would inevitably result in uncertainties of the N_{CCN} comparisons at varying supersaturations. Besides, stable lower supersaturations (SS<0.1%) are relatively much more difficult to maintain as determined by the measurement limitations of the CCNC itself. Hence, the fluctuation of the supersaturation would contribute large uncertainty to the comparison results. Details can be found in section 3.5.

7. Page 3465 Line 18-19.

The Neph measurement should be introduced briefly, not only citing references, e.g how RH is changed during each cycle (Page 3467 Line 8-11 should be moved here), etc.

Response: Thanks. We have revised it accordingly.

8. Page 3465 Line 25.

Explain why weak hygroscopic growth of particles at low RH can lead to high discrepancy at high σ condition.

Response: Taking another reviewer's suggestion into consideration, we have removed Figure 1 from the manuscript, and added the corresponding regression equation, slope and offset in the text. Consequently, we have rewritten the paragraph and discussed the possible causes of the regression slope greater than 1. More information can be found in section 2.

9. Page 3466 the first paragraph.

Re-organize this paragraph. The episodes should be described either by time or types (polluted and clean), e.g., the authors recognize the two pollution episodes, and then descriptions of these two pollution episodes should be made.

Response: Thanks for the suggestion. We have rewritten the paragraphs of section 3.1 as suggested.

10. Page 3467 Line 8-11.

Move this part to the experimental section.

Response: We have revised it accordingly, and thank you.

11. Table1.

List σ for pollution and clean episodes, so that the readers can have the idea of what was the situation in pollution and clean episodes.

Response: Thanks for the suggestion. We have provided the corresponding

information in Table 1.

12. Page 3468 second paragraph.

> The authors may want to discuss the light extinction, but did not reach any conclusion. If the authors have absorption data or extinction data or visibility, discuss all these data to investigate how much the particle hygroscopicity can affect the visibility.

Response: This work is aimed to develop a straightforward method of deriving the aerosol hygroscopicity parameter κ from the f(RH) measurements. We do not intend to investigate the influence of aerosol hygroscopicity on visibility or light extinction, as which has been discussed comprehensively in our previous work (Chen et al., Atmos. Chem. Phys., 12, 4935, 2012; details can be found in section 4.3).

13. Table 1.

> Is the average value for the whole measurement period or just for the clean and pollution episodes? It makes little sense to average only pollution and clean episodes.

Response: We agree with the referee. The "**Average**" f(RH) here represents the overall mean value for the whole f(RH) observation period.

14. Page 3472 Line 11.

> "…would be great" colloquialism. There are several English style issues in the manuscript.

Response: Thanks for the comment. We have revised it into "… is evident". Similar corrections have been made where necessary.

15. Section 3.4

Uncertainties in κ estimation should be discussed. The authors discussed the uncertainties in section 3.5, but the discussion should be moved here.

Response: We agree with the referee's suggestion. Discussion of uncertainties in the retrieved κ has been added into section 3.4. We have also revised the content in the corresponding places of section 3.5.

16. Figure 2 is unclear.

Response: Taking into account both referees' comments, we have replotted Figure 2. Time series of the dry σ_{sc} and wind parameter during the *f*(RH) observation period are presented, aiming for further analysis on the variation of *f*(RH) under different pollution episodes categorized by the wind dependence of σ_{sc}. Corresponding discussion has been revised in the manuscript.

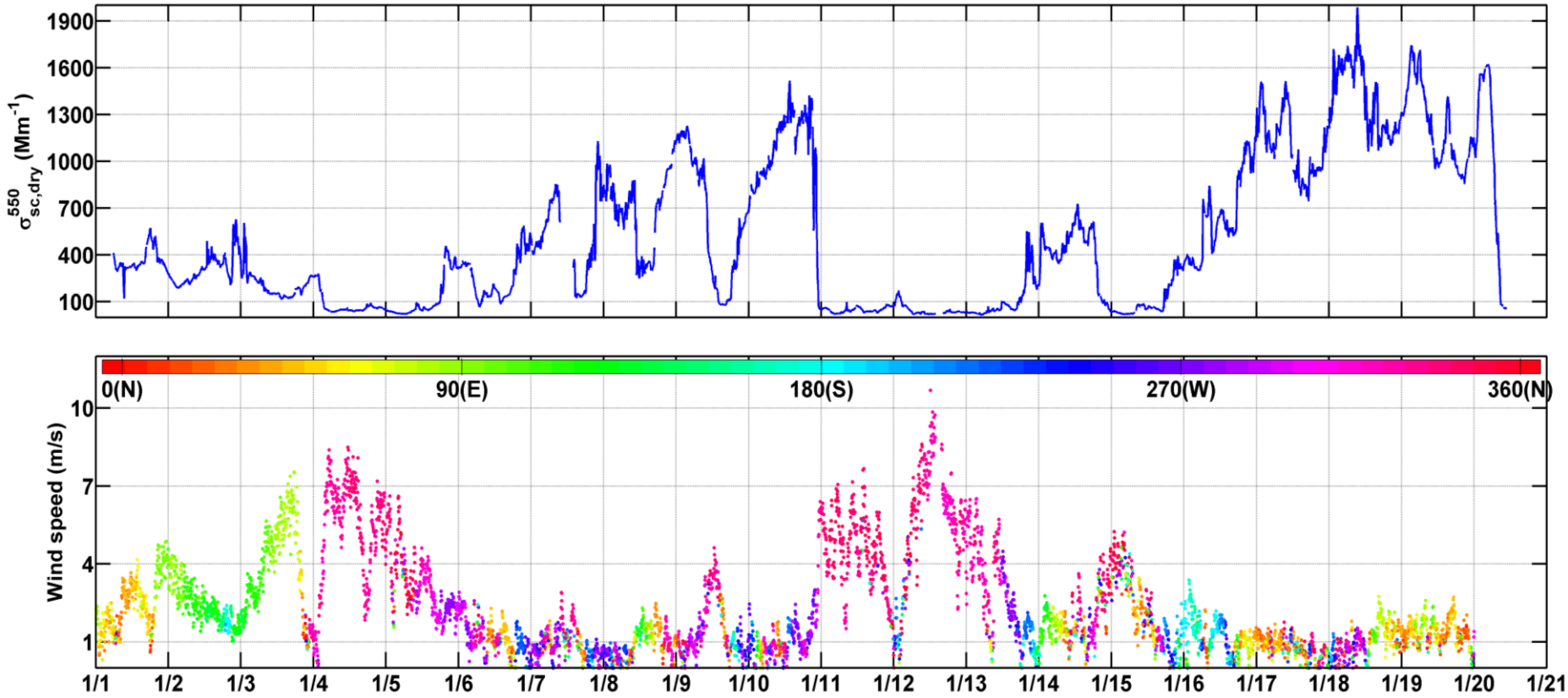

Fig.1 Every 5-minute mean aerosol light scattering coefficients at 550 nm wavelength ($\sigma_{sc,dry}^{550}$) under dry conditions, along with the wind parameter during the *f*(RH) observation periods (colored dots in the lower panel represent the corresponding wind directions).