

## ***Interactive comment on “Vertical characteristics of aerosol hygroscopicity and impacts on optical properties over the North China Plain during winter” by Quan Liu et al.***

**Quan Liu et al.**

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General comment:

The hygroscopic properties of aerosol in the polluted East Asia has been long studied from ground, but direct characterization of the vertical profile is very limited. This study provides vertical profiles of particle hygroscopicity under different meteorological conditions, by considering both particle size and chemical composition as well as evaluating the hygroscopic growth on optical properties. It provides insights in evaluating the cause of pollution especially under high moisture condition. The manuscript is generally well written. I recommend publication in ACP after addressing the following

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comments:

[Response] We thank the positive comments from the referee and we have revised modified the manuscript according to the comments point by point.

1. This work has both size and chemical composition measurements. The important message which could be delivered is the total CCN number concentration under certain SS%. It is better to highlight how much CCN could be in the highly polluted and less polluted environment.

[Response] We have added the description in lines 373-375 and give the total CCN number concentration in the highly polluted and less polluted environment as below: “The total CCN number concentration present a distinct difference between clean and polluted environment. For example, in the PBL, the averaged CCN number concentration at SS=0.05% was only  $167\pm 44$  cm<sup>-3</sup> under IRH<sub>lp</sub> period, and increased to  $765\pm 199$  cm<sup>-3</sup> under highly polluted environment, e.g., IRH<sub>p</sub> and hRH conditions.”

2. In the last section, discussion about CCN activation needs improvement, by including the discussions of CCN number concentration under different meteorological conditions.

[Response] We added the description of CCN number concentration under different meteorological conditions as below, please see lines 376-377: “For SS=0.1%, the averaged CCN number concentration increased to  $1370\pm 297$  cm<sup>-3</sup>,  $3807\pm 415$  cm<sup>-3</sup>, and  $2797\pm 438$  cm<sup>-3</sup> under IRH<sub>lp</sub>, IRH<sub>p</sub>, and hRH conditions respectively.”

3. It would be better to give some parameterizations of f(AOD) or f(RH).

[Response] We added the statement of “During the observations, f(AOD) in the PBL increased with altitude at 0.03 0.09, 2.43 per km elevation under IRH<sub>lp</sub>, IRH<sub>p</sub>, and hRH conditions respectively”. Please see lines 318-320.

Specific comments: 1. Show the location of AERONET site in Fig. 1.

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[Response] We have added the location of Peking University AERONET site in revised Figure 1, which supplied the measured AOD data in this study.

2. In Table 1. the low PBLH corresponds with high RH?

[Response] No obvious correlation between the PBLH and RH during the observations. For example, the PBLH in Dec. 17th was 500m and the surface RH was only 32%, however the PBLH in Nov. 13th reached to 1200m with a high surface RH of 85%.

3. Fig. 3 and Fig. 4, please describe the abbreviation of IRH,  $\rho$ ,  $\rho_p$  etc. in the caption.

[Response] Thanks for pointing this out. We added the description of the abbreviation in the caption of Figure 3 and Figure 4.

4. Fig. 5, please provide the effective diameter in the figure.

[Response] We add the effective diameter under different conditions in Figure 5.

5. The labels are too small for Fig. 7., the whole figure needs to be made larger.

[Response] We adjusted the Figure 7.

6. line 316-318, how consistent with dry size?

[Response] The vertical profiles of dry aerosol effective diameter ( $D_{eff}$ ) are shown in Figure 4b. As it shown, the  $D_{eff}$  increased with altitude in the PBL for all conditions, which were consistent with the variations of aerosol hygroscopic parameter ( $\kappa$ ). We revised the related discussion, please see lines 326-327.

7. Line 355-357, SS=1% can be deemed to be in convective system, a stratus may not reach as high as 1%, need to rewrite this part.

[Response] We note that the statement of “the supersaturation (SS) for status clouds in clean condition often exceeded 1%” is not accurate. We have rechecked some of the literatures that the max SS for stratus clouds over polluted continental regions usually be slightly less than 0.1% during wintertime (Hudson and Noble, 2014; Hudson et al.,

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2010). We thus discussed the CCN activity at SS=0.05% and 0.1% respectively. We have revised that statement.

8. Line 409, framework.

[Response] Revised.

9. the letter size in some figures are too small, please make them readable

[Response] Revised.

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