## Reply to Reviewer #1's comments

*Liquid water cloud plays an important role in the Earth's atmosphere, while a great deal of uncertainty still exists in observational cloud properties. Cloud droplet number concentration ($N_d$) is one of the most important cloud properties, which associate clouds with aerosol. This study compared four ground-based $N_d$ retrievals from both lidar and radar retrievals with in situ measurements and investigate seasonal variations of $N_d$ and $r_e$. Their results showed good agreement between ground-based retrievals and in situ measurement for overcast conditions. Also, the consistency between $N_d$ retrievals and in situ measurement struggles with broken or low LWP clouds. By extending these retrievals to longer time period, obvious seasonal variations of $N_d$ ($r_e$) values exhibits and are consistent with previous researches. I believe their evaluation promote our understanding of uncertainties of remote sensing data. However, the paper needs to be improved to be qualified for publication by addressing the following comments.*

**We thank the reviewer for these constructive suggestions and comments. We carefully revised the manuscript according to the reviewer's comments.**

*General comments:*

1. *Line 93-94: I think you need add more details about why you choose these four ground-based $N_d$*

   **Response: We appreciate the reviewer's suggestion. Our analysis encompasses four major ground-based $N_d$ retrievals. We have updated the statement in line 100 to reflect this. Furthermore, in line 98-99, we emphasized the significance of these retrievals with the sentence of 'considering their potential for operational applications and ease of use across different locations '. However, we did not include lidar-based $N_d$ retrievals that either utilize dual-field-of-view lidar extinction profiles or rely on depolarization measurements from lidar multiple scattering. This is due to the specific requirement of the dual-field-of-view lidar configuration and the substantial calibration efforts needed for lidar depolarization measurements. We've incorporated this clarification into the manuscript in line 102-108.**

2. *Line 121: literatures or documents of the instruments' information showed in Table1should be cited here.*

   **Response: We added references to these instrument handbooks.**

3. *Line 207-210: This sentence is not easy to read. You may consider reorganizing the sentence structure to simplify and make it clearer.*

   **Response: We reorganized the sentence structure to make it clearer.**

4. *Line 214: you assume a linear increase of LWC in radar retrievals. Are there any impacts of this assumption to the results without regard to $f_{ad}$ in this situation?*

**Response:** We appreciate the reviewer's comment. Given that both LWC and $\sqrt{Z}$ are influenced by $f_{ad}$ in a consistent manner, $f_{ad}$ doesn't affect radar-based $N_d$ retrievals.

5. *Line 218: you missed $\rho_w$ in equation 7 according to Mace (2000).*

   **Response:** We added $\rho_w$ in equation 7.

6. *Line 232-233: I think you should explain more about the meaning of k\* and point out why use k\* to replace k.*

   **Response:** We added a sentence to explain the meaning of $k$\* in line 263:

   **'$k$\* is the cloud system $k$ parameter, which is the cube of the ratio between the layer-mean volume radius and the layer-mean effective radius.'**

   **In line 264, we referenced Brenguier et al. (2011), noting, 'As both $\tau$ and LWP represent vertical integrals through the entire cloud layer, Brenguier et al. (2011) propose using the cloud system $k$\* parameter in place of $k$ in equation (8)'. Consequently, the NDROP VAP retrievals utilize the cloud system $k$\* parameter, while other methods deploy the local mean $k$ parameter. We added this sentence in line 265-266.**

7. *What do the black circles mean in figure 4b?*

   **Response:** Black circles represent islands in the region in Figure 4b. We added this clarification in Figure 4b's caption.

8. *Line 365: the word "greatest" may cause misunderstanding. You should replace it with another word.*

   **Response:** We rewrote the sentence as: '$N_{d\_vap}$ retrieval exhibits the highest values'.

9. *Line 380: I notice that the higher $N_d$ from in situ measurements actually appear on 02/07/2018, 06/30/2017 and 02/12/2018. If you have a specific criterion, you should point out here.*

   **Response:** We revised the sentence as following:

   **'with generally higher $N_d$ observed on summer IOP days, and lower $N_d$ on winter IOP days'**

10. *For more intuitive and easy reading, I think you should label the broken conditions in Table 3 and other figures that appears the date of 12 flight days.*

    **Response:** We appreciate the reviewer's suggestion. We added a * to label broken conditions in Table 2 and 3, and Figure 6.

11. *Line 412-414: what are the possible causes of the inconsistency of $r_{em}$ and $N_d$ retrievals of NDROP VAP compared to FCDP?*

   **Response: We thank the reviewer for raising the question. We realize that the values of $r_{e\_vap}$ are also slightly greater than those of $r_{e\_FCDP}$ in general. This is primarily because $r_{e\_vap}$ is calculated from measured LWP and $\tau$, both of which are more heavily influenced by the cloud's upper regions where larger droplet particles are prevalent. We revised the sentence in the manuscript.**

*Detail comments:*

1. *Line 28: delete the repeated "using the".*

   **Response: We deleted the repeated words as suggested.**

2. *Line28-30: this sentence has a linguistic flaw. I suppose you may want to begin a new sentence from "given".*

   **Response: We changed the sentence structure by starting a new sentence for the reasons why we recommend the Micropulse lidar-based method.**

3. *Line 59: cloud optical -> cloud optical depth*

   **Response: Thanks for pointing out the typo. We changed 'cloud optical' to 'cloud optical depth' in the text.**

4. *Line 95: 2018 -> 2017*

   **Response: We changed it from '2018' to '2017 as suggested.**

5. *Line 219: Miles -> Mace*

   **Response: Our equation was sourced directly from Miles et al. (2000). We realized we omitted the reference to Miles et al. (2000) in our initial reference list and have now included it in this revision.**

6. *Line 289: missing 'cloud depth' in your statement of figure 1.*

   **Response: We added 'cloud depth' in that sentence.**

7. *Line 293: figure 1c -> figure 1d*

   **Response: We changed 'figure 1c' to 'figure 1d'.**

8. *Line 421: full name of TSI should be presented in your main body.*

   **Response: We added the full name of TSI in the sentence.**