Summary

This study presents a methodology for characterizing vertical heterogeneities in aerosol type/properties. It then quantifies how these heterogeneities impact the accuracy of vertically resolved CCN from the RNCCN method via comparisons with ground-based and airborne in situ CCN observations. This work demonstrates that the vertical aerosol uniformity assumption underlying the RNCCN retrieval method can cause large errors in certain conditions. The method is also presented as a way to enhance or better use/interpret the RNCCN product. The paper is very well written, and I appreciated that the hypothesis and the main goals of the paper were presented up front in the paper and were explained very well. I also felt the data section was written very well and was very easy to follow. I have some minor comments for clarity of various details.

Minor Comments

- **Introduction**
  - Line 58: Somewhere it might be good to mention aircraft-based lidar approaches as well as a third category.
  - Line 70: Are there other papers in addition to Ghan et al. (2004) that could be cited as examples of this method?
    - This is one recent example I'm aware of that also uses ARM observations: Chen, B., Thompson, S. A., Matthews, B. H., Sharma, M., Li, R., Nowotarski, C. J., Rapp, A. D., and Brooks, S. D.: A new technique to retrieve aerosol vertical profiles using micropulse lidar and ground-based aerosol measurements, Atmos. Meas. Tech., 18, 5841–5859, https://doi.org/10.5194/amt-18-5841-2025, 2025.
  - Line 101: Other recent ML + lidar papers: Redemann & Gao (2024); Ferrare et al. (2025)
- **Data**
  - A brief description in this section of the SGP location and what aerosol types/meteorological conditions were observed during the HI-SCALE campaign would provide the reader with a bit more context.
  - What are the approximate average uncertainties for the Raman lidar observables and in situ CCN concentration?
  - Line 189: It is mentioned that the RNCCN dataset excludes observations with RH>85%, such that hygroscopic growth corrections are not included. While (vertical) variations in aerosol type are one major cause of CCN retrieval uncertainty, hygroscopic growth also increases error when retrieving CCN

from optical properties. Although not a focus of this study, it may strengthen the paper to add some mention of this as a limitation/source of uncertainty/possible area for future work in the summary, especially since this threshold will exclude observations in very humid near-cloud environments that are relevant for ACI.

- **Methodology**
  - Line 218: On first read, I interpreted the DeLiAn database as a lookup-table approach, which made the role of the kNN classifier somewhat unclear. I think I'm understanding now that 1) it isn't a lookup-table and 2) a model is being trained using the DeliAn dataset as "truth" values so that it can predict an aerosol type classification using only the ARM lidar observed LDR and LR as input. If this is the case, I think a bit more direct explanation of the process/connection here would be helpful up front, because it took me a while to understand this.
  - Line 241: "cruises"
  - Line 245: May need to remove either "database" or "based"
  - Line 294: This first sentence is a bit repetitive from what was already stated a couple of paragraphs before.
- **Results and Discussions**
  - Seeing marine classifications for Oklahoma observations will immediately catch a reader's attention in this section, and the explanatory work shown in Appendix D should be referenced sooner. Right now, I'm only seeing Appendix D referenced in Appendix C.
  - Line 389: I may be misinterpreting the figure, but I'm seeing a bigger difference in the RNCCN and G-1 observations in the two scatter points after 19.5 UTC.
  - Line 443-447: By "one valid G-1 CCN measurement," does this mean a single 1 Hz observation or one 10-min average?
  - Figure 6: It is not clear to me from the writing that these (I believe) are daily averages. I assume since 20160915 has two points (for two flight segments) that data for other days only comes from one flight segment? It would also be helpful to know how many valid windows are included in each daily average.
  - Line 507: Maybe change "structure" to "variation?"