Summary

This paper uses observations and modelling to discuss the impact of aerosols on cloud properties at different heights within liquid, mixed-phase, and ice clouds. The main finding is that an increase in aerosol concentration shifts the cloud droplet spectra from bimodal to unimodal. I thought the authors did a good job of discussing and explaining their figures and the mechanisms behind these aerosol-cloud interactions. Most of my comments are about additional details needed in the Data and Methods section and the way that Figure 3 is presented.

Major Comments

- One of my main concerns with this paper is **Fig. 3** and the claims drawn from it. Presented with scatter points, I struggled to find most of the authors' claims to be evident from the figure, especially in panels b, c, i, j, k, and l. I would suggest presenting these figures as bin-averaged line plots with error bars or shading to represent variability in the observations to make the claims in Sect. 3.2 more obvious from the figure. I really felt like I needed a line for each subset to be able to compare and see/understand the patterns. Panels o and p in this figure are also switched compared to all other rows.
  - Additionally, it was difficult for me to keep track of rows and columns in Figs. 2 and 3, and it would be helpful to label these on the figures.
- The **data and methods** section would benefit from more detail about the following:
  - Aircraft observation platform and instruments:
    - What size droplets are measured by the CDP?
    - What meteorological variables are used from the AIMMS-20?
    - Does the AE-33 need to be mentioned if no data from it is used in the rest of the study (as far as I understood)?
  - Data processing:
    - Can you be more specific or provide a map of where these flights took place? What aerosol types are expected in this region (rural vs. urban)?
    - All equations need to be numbered.
  - Cloud phase determination:
    - What does "normal" mean in Line 150? Does this refer to a lognormal distribution or continuous as opposed to piecewise?
    - I see details about how the small and large size ranges are defined in Lines 166-167, but I think it should be defined before the fitting in Fig.

1 (Lines 151-156). Additionally, how many observations does the fit in Fig. 1 represent? How many days/flights are accounted for there? Are they for all cloud phases?

- Several details in the **results** would also benefit from more detail and motivation:
    - I am not clear about how the high and low aerosol concentration groups (Line 174-175) or the different cloud layers are determined (Line 185).
    - I am unclear about the purpose of splitting data in column 3 of Fig. 2 into separate distributions for both high and low aerosol concentration. It seems this makes the "low concentration" line noisier, presumably because there is less data. It may help to combine those or better motivate the split.
        - Fig. 2: It is not clear from the text or caption why there are two rows for ice clouds. Column 3 is not described in the caption. The colors for cloud top, middle, and base also need to be fixed in the caption to yellow, green, and purple. Additionally, would it be possible to show values of spectral width as calculated in the methods? This might be more intuitive than a visual determination of spectral width (Line 184).

Minor comments

- Line 13-15: Can you make it explicit that you are describing droplet size at which number concentration peaks? As it reads right now, I was expecting to see peak number concentration values.
    - Lines 16-17: Similarly, can "concentrations within the intermediate range" be specified to mean intermediate droplet sizes? Unless this is referring to something else.
- Line 23-24: It looks like this sentence got cut off here.
- Line 28-31: You might consider rephrasing to say that when aerosols act as CCN and IN, this results in modulation of cloud properties. Current phrasing makes it sound like these are two separate processes.
- Line 49-50: Can you give a brief example of these significant findings?
- Line 54: It looks like there is an error with this reference.
- Line 69: Need to define E3SM.
- Line 105 and 108: I would not refer to the number concentration within individual size channels as a "distribution." Additionally, do you have a reference for this N_i equation or can you describe it in a bit more detail? This is not a conversion I have seen before.
- Line 117: "Channel" is repeated twice.
- Sections 2.3 and 2.4 have the same title.

- Line 167: Critical diameter usually refers to the size needed for CCN activation. Is that the same way it's being used here?
- Line 171: Can you specify what environmental conditions you're referring to here?
- Line 179: Are these aerosols actually measured "in" cloud, or should this maybe be "below?"
- Line 247: Can you elaborate a bit on what you mean by saying the CCN concentration is "insufficient?"
- Line 272: Before describing the finding from Fig. 6 can you explain what is plotted and what you're trying to assess with it?
- Line 272-275: I do not understand the claim that effective diameter and spectral dispersion both increase as aerosol concentration increases but then they decrease. From this figure I see a levelling-off, but it is not obvious to me that either quantity is decreasing.
- Fig. 7: Might it make more sense to present and label the middle row as supersaturation? Also, VMR is undefined.