Main comments

RC1: Line 45-50 – Both holography and shadowgraphy are mentioned, but examples are only from holographic instruments. Shadowgraphy could also be instruments such as 2D-S, HVPS, CIP, etc. There is also a big difference between the two, shadowgraphy records shadow images while holography records holograms that need reconstruction to give the equivalent to in-focus shadow images.

AC: We have added text/references for shadowgraphy as follows

L45: "Instruments in the former category are, e.g., the forward-scattering spectrometer probe (FSSP), the cloud droplet probe (CDP), and the fog droplet spectrometer (FM-100 and FM-120, Droplet Measurement Technologies) (e.g., Knollenberg et al., 1981; Baumgardner et al., 2011, 2014) and those in the latter category, e.g., the Cloud Particle Imager (CPI) (Lawson et al., 2001), the 2D-S (Stereo) Probe (Lawson et al., 2006), the Cloud Imaging Probe (CIP) (Droplet Measurement Technologies Inc., USA), the Oxford Lasers VisiSize D30 (Nowak et al., 2020), the Holographic Detector for Clouds HOLODEC) (Fugal and Shaw, 2009), the HOLographic Imager for Microscopic Objects II (HOLIMO II) (Henneberg et al., 2013), HOLIMO 3G (Beck et al., 2017), and HALOHolo (Lloyd et al., 2020)."

RC1: Line 52 – Some in-situ instruments (such as the ICEMET) are open path and don't have an inlet as such, there is still loss, but I'd say it's due to air flow around the housing. I'd rephrase that sentence.

AC: We have improved text about sampling losses and modify text as follows

L52: "In all in-situ instruments which use inlet for sampling, a part of the sample is lost along the line between the sampling inlet and the detector. One point of interest is the difference between the flow rate in the inlet and the prevailing wind speed and direction."

L63: "In the instruments which utilize an open path sampling, such as CDP, CIP, and ICEMET, sampling biases may also be caused when the housings of instruments alter the airflow around the housing causing local flow speed and direction changes. The droplets may react to these airflow changes differently depending on their size."

RC1: Line 72 – Please clarify: 6-10 um is the minimum detection size, which is twice the effective pixel size (as stated in line 118). This is because at least two dark pixels along one axis of the hologram are necessary to separate noise from particles, sometimes more, especially in high noise holograms.

AC: We decided to improve definition of the minimum detection size in Chapter 2.1 and simplify text in Introduction as follows

L71: "The minimum detection limit of the whole sample volume in holographic instruments is a design compromise with the desired sample volume per hologram used. For these holographic instruments, the minimum particle detection limit varies between 6 µm and 10 µm."

L118: “The minimum particle detection size is defined as two times the effective pixel size. This is because at least two dark pixels along one axis of the hologram is needed to separate noise from particles, sometimes more, especially in high noise holograms.”

RC1: Line 190 – Why do you not reconstruct those window splashes and discard them? Or are they impacting the entire sample volume, masking real drops?

AC: The whole volume, including the windows are reconstructed in the segmentation & analysis phase but as the reviewer commented, the large splashes from large raindrops on the windows mask the cloud droplets in the measurement volume. The holograms with large raindrop splashes on the windows are detected in the segmentation phase as holograms with a large number of contours. If over 2000 contours are found, that hologram is rejected based on the set max 2000 contour rule. Smaller splashes on the windows do not affect the segmentation and analysis phases.

RC1: Fig 6 – How many data points are there per wind direction? Is one direction favored?

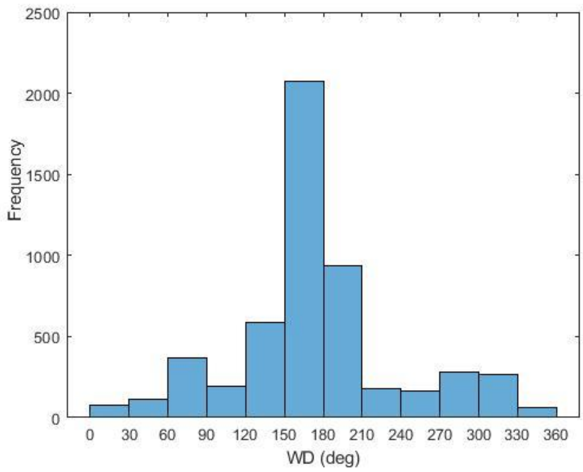

Figure 1: Number of data points for different wind directions in the period of measurement campaign 3. September – 3. November 2020.

AC: The dominant wind direction was around 160° (Fig. 1) during the two-month measurement campaign (L287-288). The number of data points was greatest for the wind directions of 120°−210° and the smallest for the wind directions between 330° and 360° where the amount of data points was 61. Although the number of data points varied with the wind direction, there were enough data for comparing the cloud microphysical properties for varied wind directions when a bin width of 30° was applied.

RC1: What is the upper size limit of ICEMET? This will be important to assess the LWC and MVD, since it is higher than the upper size limit of the FM120 and large drops impact LWC and MVD heavily.

AC: The ICEMET can measure particles up to the size of the camera sensor, which corresponds to maximum diameter of approximately up to 2 mm diameter inside the measurement volume, but the results are filtered so that the upper size limit (equivalent diameter) of the detected particles in the results is 200 µm.

RC1: *Section 3.2.3 – The underestimation of the FM120 in terms of LWC is probably also due to the fact that ICEMET sees larger drops than FM120, which contribute most to LWC, correct? You only mention the rotating inlet as a reason.*

AC: We thank for the relevant comment. We have improved the manuscript text as follows (from line 431):

L431: "On the contrary, if cloud formation occurs with low aerosol loadings, the droplet spectrum moves to larger droplet sizes (e.g., clean air mass), and the mutual information shared by the three data sets increases. In this case, larger droplets with a diameter above 50 µm are unaccounted for by the FM-120 and the twin-inlet system but are detected by the ICEMET because its upper size limit is 200 µm. The large droplets increase the LWC_{IM} and MVD_{IM} which may cause disagreement between the ICEMET and FM-120 observations, especially during clean air mass in-cloud periods when droplets are typically larger. However, during this measurement campaign, the occurrence of larger droplets was quite small, and their effect on the average LWC and MVD were 2.1% and 1.9%, respectively."

Suggestions for Figures for easier understanding

RC1: Generally, Figures are good quality. However, some could be improved to guide the reader. Here are my suggestions:

RC1: Fig 3a and Fig 10 – Adding a one-on-one line might be useful to see the deviation from the ideal case.

AC: One-on-one lines were added in Fig. 3a and Fig. 10.

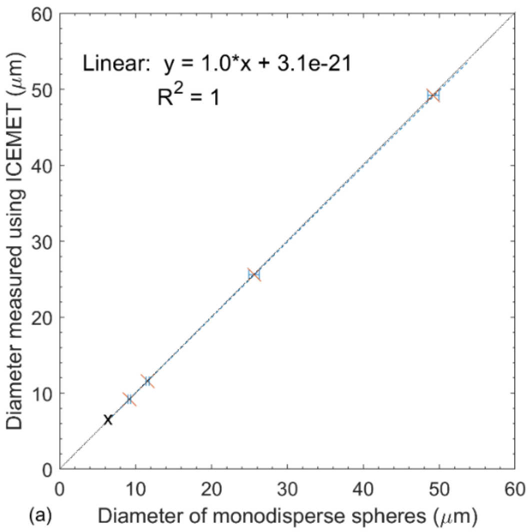

Figure 3a

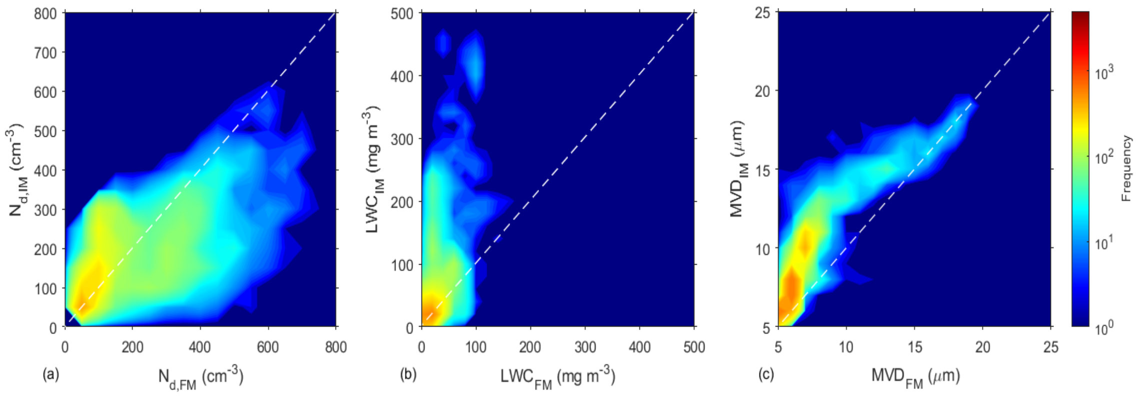

Fig. 10

RC1*: Fig 5 – It might make sense to put the red line in all panels to mark the smoke periods.*

AC: The red lines were added in all panels

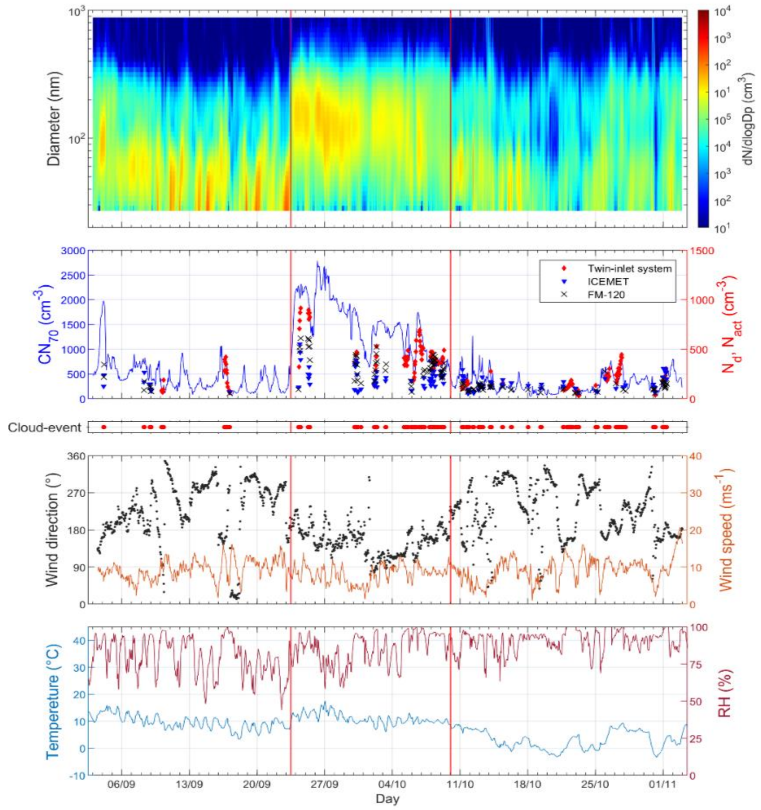

Figure 5

RC1: *Fig. 8 – The data points might be easier to look at if the axes were loglog.*

AC: Fig. 8 axes were modified to loglog -scale.

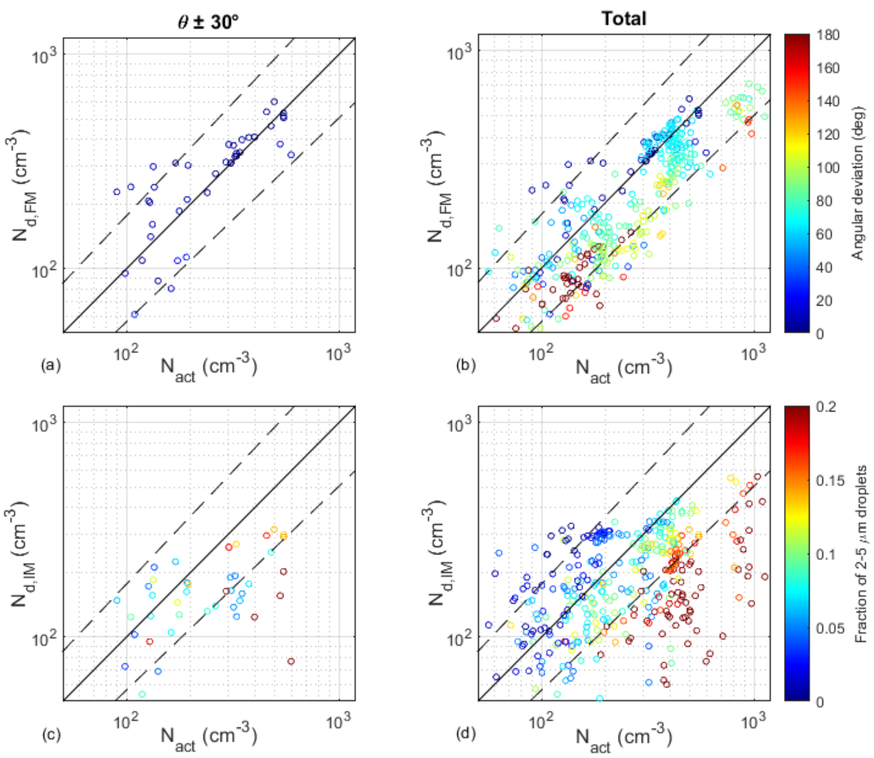

Figure 8

Language

RC1: Overall, the language is good. However, please check spelling and grammar carefully. Here is a list of things I found:

RC1: Line 79 – The abbreviation DMPS has not been defined yet at this point.

AC: We simplified the sentence in the revised version and removed the abbreviation DMPS, because it is not necessary in this chapter (overview).

AC, L77: "In this paper, we intercompare the novel instrument ICEMET (Icing Condition Evaluation Method; Kaikkonen et al., 2020; Molkoselkä et al., 2021) to parallel measurements with a cloud spectrometer (FM-120) and to the cloud properties calculated from particle size distribution measurements (a twin-inlet system) utilizing on ground-based field measurements in Puijo, Station for Measuring Ecosystem-Atmosphere Relations (SMEAR IV), station."

RC1: Line 144 – Dt is \Delta t in equation 1. Same in lines 205/210, I believe.

AC, L144,205: We have changed Dt to Δt.

AC: Line 144: "...Va is the analyzed volume (cm^3), and Δt is the sampling duration (s), and m is the total number of size channels. Sampling volume (V_s) is.."

AC: Line 205: "…volume (V_s) was around 19 cm^3 with a 5 s integration time (Δt) (maximum sampling rate of 20 Hz) and the detector in-focus.."

RC1: Line 251 – spelling ("covariability")

We have corrected the spelling.

Line 251: "The mutual information (MI) between two data sets X and Y measures the X-Y covariability or the amount of information…"

RC1: Line 258 – Here, you state that MC and MI are the same, but you use both in different equations. Please make this consistent.

AC: We thank the reviewer for noticing this detail. This indeed can confuse the reader. MC for mutual correlation has been applied along the text in the corrected manuscript.

L21: "..confirmed by mutual correlation and Pearson.."
L80: "We also use mutual correlation analysis.."
L250: "**2.5 The mutual correlation analysis"**
L251: "The mutual correlation (MC) between two.."
L258: "Therefore, the mutual correlation MC(X,Y) can be expressed as.."
L263: "The MC is a robust statistical.."
L274: "We performed a MC analysis.."
L387: "**3.2.2 The mutual correlation analysis"**
L397: "Results of the mutual correlation analysis.."
L402: " ..from the MC by each instrument with the Twin-inlet system."
L419: "While mutual correlation analysis can detect any kind of dependence,.."
L427: "In summary, it is expected to have MC below 1 due to.."
L432: "..and the MC between the three-data sets increases."
L457: "This agreement was also confirmed by mutual correlation analysis and Pearson correlation coefficients."

RC1: Line 282 – check grammar – please rephrase

AC: We simplified sentence as follows

AC: L282: "The criteria for the occurrence and intensity of cloud are typically visibility, N_d, LWC, or N_d and LWC together (Portin et al., 2009, Ragno and Hobbs, 2005, Hoyle et al., 2016, Li et al., 2020)."

RC1: Line 325 – spelling ("...ICEMET observed…")

AC: We have rewritten the sentence

AC: Line 325: "… properties and shapes, but ICEMET detected wider DSD_{IM} values especially…"

RC1: Line 374 – check grammar – please rephrase

AC: We have rephrased the sentence as follows

AC, L374: "An in-cloud period on 2 November 2020 was chosen to intercompare the ICEMET and the FM-120 in more detail (Fig. 9)."

RC1: Line 375 – AMT guidelines suggest specific date format (dd month yyyy, as used in line 383)

AC: We have rewritten date format

L375: "…cloud period on 2 November 2020 was chosen.."

RC: Line 485 – space missing in "...Korolev, A.,Krämer, M.,…"

AC: We have added the missing space in the reference

Baumgardner, D., Brenguier, J., Bucholtz, A., Coe, H., DeMott, P., Garrett, T., Gayet, J., Hermann, M., Heymsfield, A., Korolev, A., Krämer, M., Petzold, A., Strapp, W., Pilewskie, P., Taylor, J., Twohy, C., Wendisch, M., Bachalo,W., and Chuang, P.: Airborne instruments to measure atmospheric aerosol particles, clouds and radiation: A cook's tour of mature and emerging technology, Atmos. Res., 102, 10–29, doi:10.1016/j.atmosres.2011.06.021, 2011.

References

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Nowak, J. L., Mohammadi, M., and Malinowski, S. P.: Applicability of the VisiSize D30 shadowgraph system for cloud microphysical measurements, Atmos. Meas. Tech., 14, 2615-2633, doi:10.5194/amt-14-2615-2021, 2021.