We would like to thank the reviewers and editor for studying carefully the responses and improvements we did on the manuscript and for their further comments and suggestions. We include below the comments of Referee #1 in black and our responses in blue. Copied text from the manuscript is marked in italics and underlined sentences correspond to changes in the manuscript.

Questions and responses to Referee 1

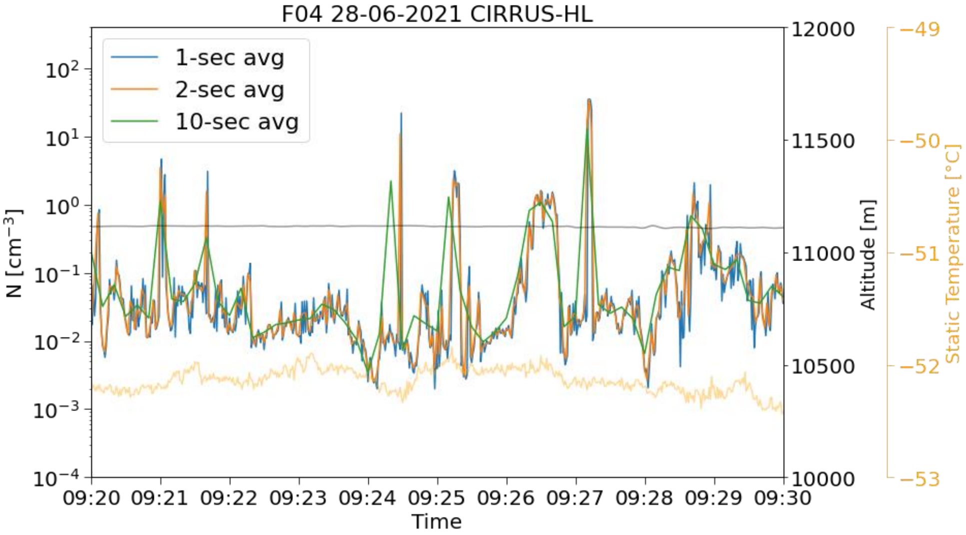
Review of revision “Differences in microphysical properties of cirrus at high and mid-latitudes”, EGUsphere 2023-374, by Castro, Jurkat-Witschas, Afchine, Grewe, Hahn, Kirschler, Kramer, Lucke, Spelten, Wernli, Zoger, and Voigt.

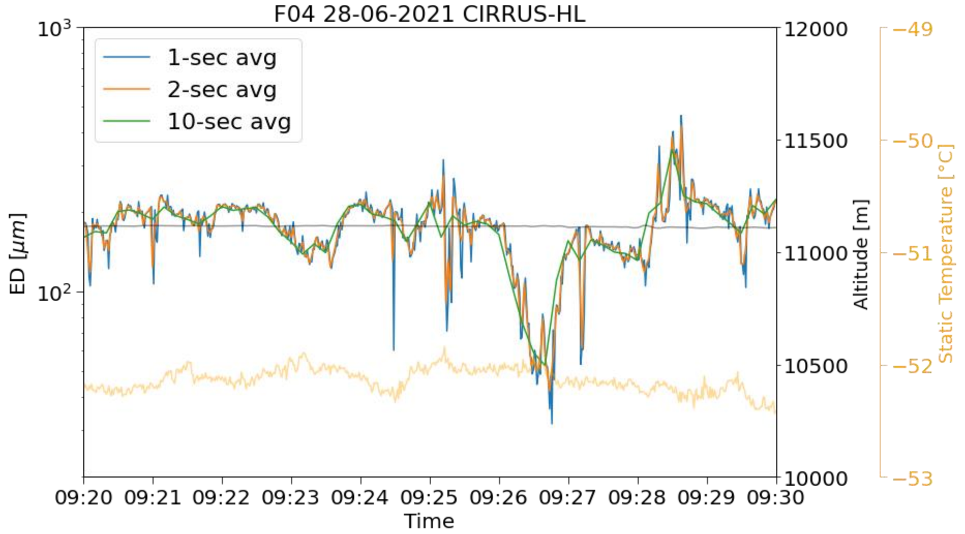
Overall, I like your responses to my comments. I have a few points below.

We thank the reviewer for his positive assessment.

The suggestion to use 10 second averages is because low concentrations of small particles may not be included in particle size distribution representations. 0.025 cm-3 (one particle sampled by the CDP is 25/liter. That’s typically the total concentration of cirrus ice particles. Perhaps you could do a simple 10 second averaging to see what the effect would be. I do recognize that the path length of this 10 second sample may be 2 km but, that’s okay for this exercise.

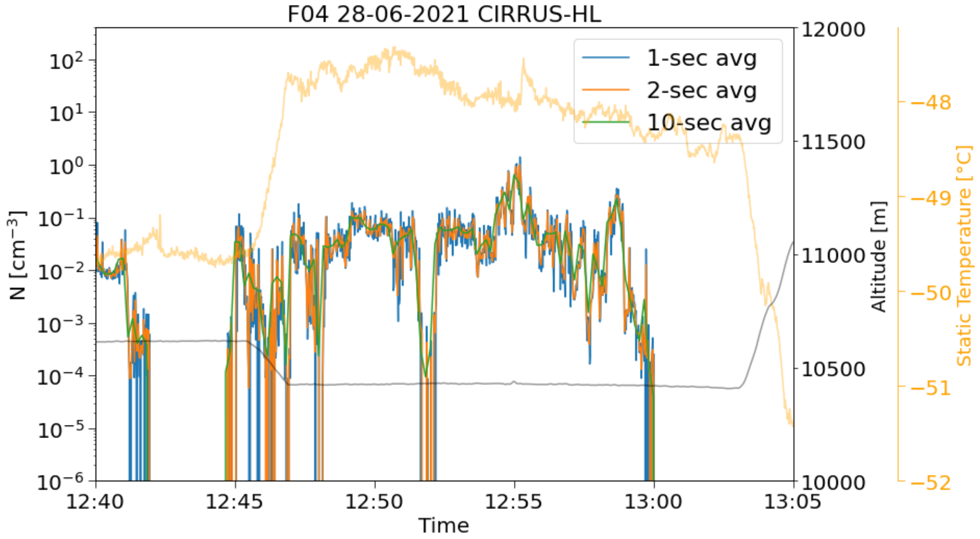
Following the reviewer’s and editor’s suggestion to provide a simple comparison of the three averaging options (1s, 2s and 10s) we looked at two examples to better illustrate the differences and compare the number concentration (N) and effective diameter (ED). The first example (first 2 graphs) shows 10 minutes of a continuous cirrus sequence with some embedded contrail crossings (with enhanced N over 1cm-3 and a reduction in ED). The measurement occurred at constant altitude (around 11 km, gray line) and temperature (around -52 °C, yellow). The blue, orange and green lines represent the N for 1, 2 and 10-sec averages. We observe that both 2-s and 10-s follow the profile of the 1-s line, but the 10-s line often locates the N peak wrongly and sometimes even misses it, while the 2-s reduces slightly the maximum values but reproduces correctly each peak. The 10-s averaging for the ED shows more clearly that the reductions in the ED are not captured.

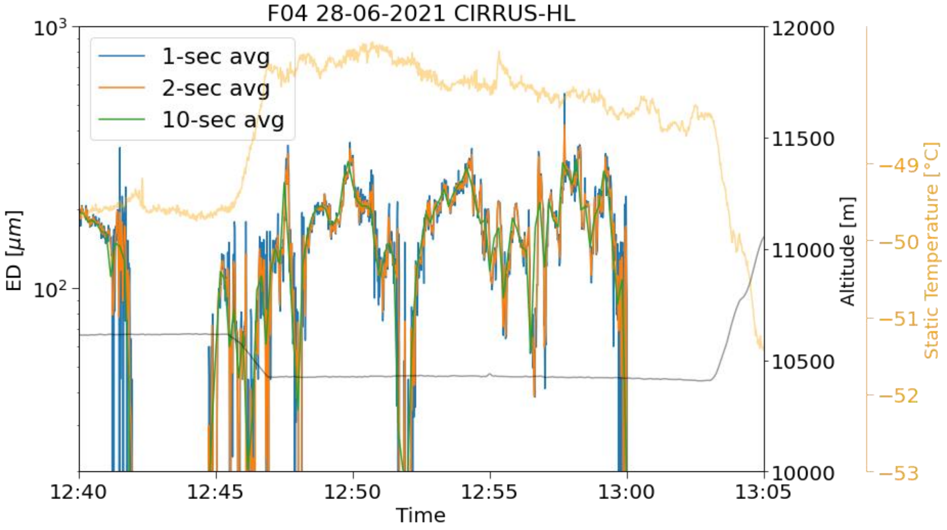




The next 25 minutes sequence shows the end of a cirrus leg and captures another one at a lower altitude and higher temperature, with also slightly higher N. We also observe that in this case, there are some patches where the cloud is not homogeneous and has very low number concentration with erratic time instants of free air. The 2-s average line, in this case, helps to smooth the scatter in these patches, as well as at the beginning or end of a cloud sequence. In the end, we find that 2-s average does not differ much from the 1-s and therefore makes it comparable to other studies, which usually show cloud properties in 1Hz and, at the same time, gives us the advantage to slightly homogenize certain features, particularly in regions of low concentrations. Depending on the purpose of the study, 10-s average could be an interesting choice. However, in our case, the 10-sec average would homogenize too much and avoid the identification of contrail encounters, which was also an object of our study. We include in the manuscript the following sentences to clarify the choice of 2-s average:

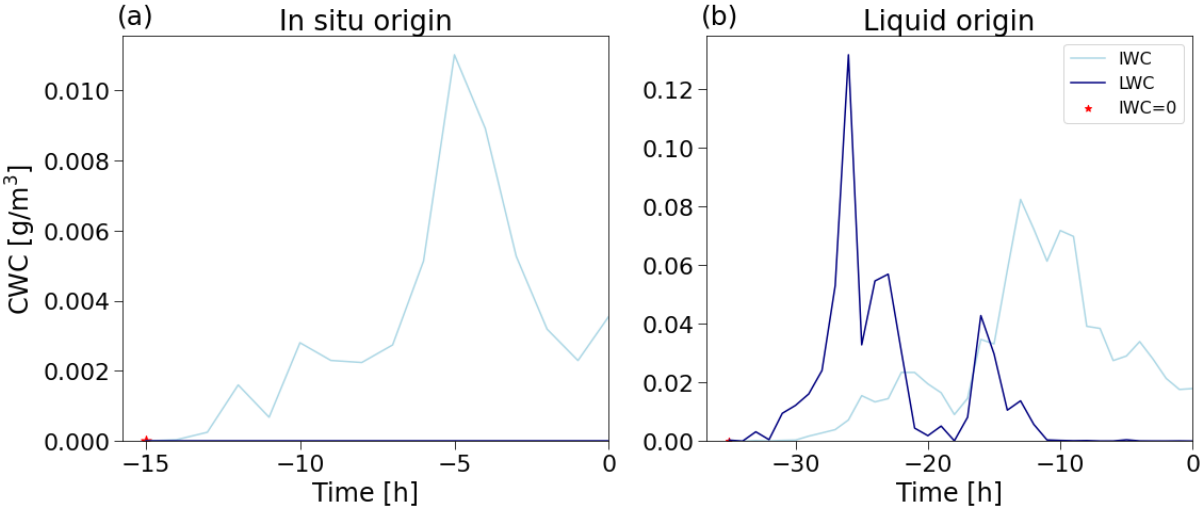
In general, studies usually use data directly in 1-Hz sample rate. We apply a 2-s mean in order to improve the statistical significance of the low particle concentrations. A larger averaging interval (e.g. 5 or 10 seconds) corresponds to a large horizontal extension (~ 2 km for 10-s averages), where local inhomogeneities can be present, and therefore, it excessively attenuates certain features that are of interest, such as contrails, for example.





Liquid origin. If your suggestion that "liquid origin cirrus" is reasonable, you should plot out the aircraft vertical velocities during the penetrations. Do you see updrafts >0.25 m/s approximately that could be used to check your hypothesis about liquid origin cirrus.

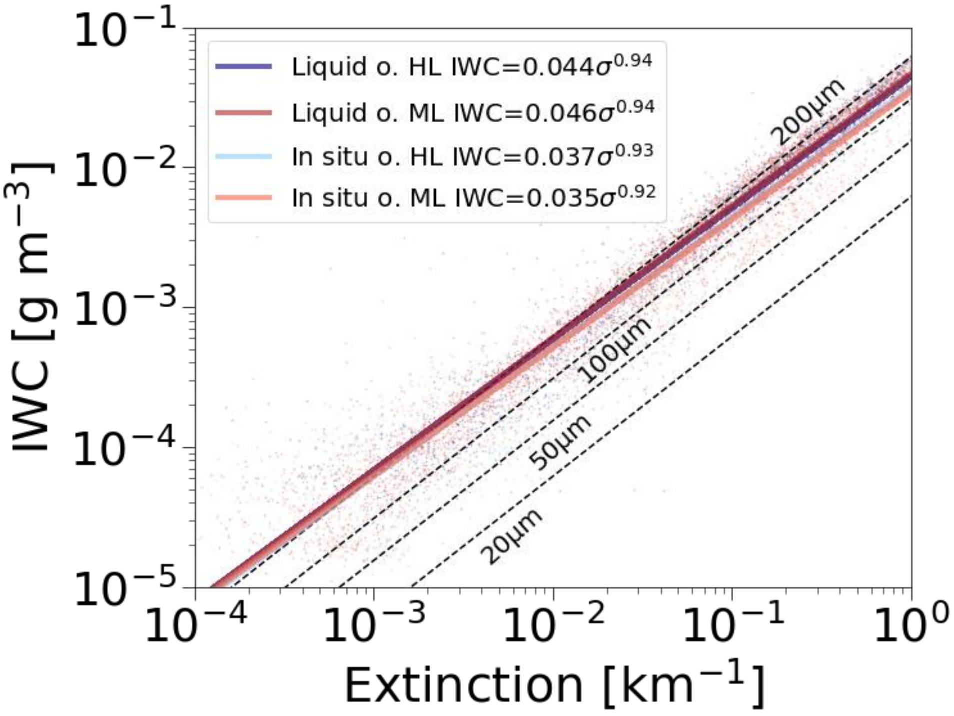
To determine whether the cirrus we measured were of in situ or liquid origin, we use the definition from Luebke et al., (2016), Krämer et al., (2016) and Wernli et al., (2016). In particular, we applied the method described in Wernli et al., (2016), which uses backward trajectories to verify the presence of liquid or ice water content (LWC/IWC). In the graphs below, we show an example of the cloud water content (CWC) along two backward trajectories, one corresponds to an in-situ origin cirrus (a) and the second one refers to a liquid origin cirrus (b). The red star marks the cloud formation. We classify the measurements associated to trajectory (b) as liquid origin, since LWC content was present at some point since the cloud formation point. Therefore, we do not set here a requirement for the updrafts. For example, in this case, the maximum value of the updraft along the trajectory is ~ 0.09 m/s. We briefly discuss in the text about the updraft velocities regarding the Fig. S3 (originally S2) in the Supplement, where we show frequency distributions of the updrafts along the backward trajectories and at the measurement points for the four groups (in-situ origin ML cirrus, liquid origin ML cirrus, in situ origin HL cirrus and liquid origin HL cirrus). The maximum values along the trajectories are higher for the liquid origin groups than for the in-situ origin. When considering all values along the trajectories, we also find broader distributions for the liquid origin cases. However, the trend becomes less clear when looking at the instantaneous updraft measurements. We do not find very useful the measurement of the vertical velocities during the penetrations, since they are just as snapshot of the "present" moment and do not provide much information about the cloud history. In an aged origin cloud, it would be a weak indicator of its origin or formation pathway.



Your responses to Darrel Baumgardner's review are good. We'll let him comment on that.

Figure 8. Could you add another panel (d) that shows the relationship between extinction and ice water content for the different combinations.

We thank the reviewer for this suggestion and the following plot shows the relationship between the extinction coefficient and ice water content for the four groups, as defined in Fig. 8 from the text. The linear fits of the four groups matches the ED=200 µm line and the slope of the fits are slightly below 1. A small difference between the in situ and liquid origin cirrus groups can be observed, for the same extinction, the IWC of the liquid origin cirrus is larger, what is in line with previous observations and the results of our study. We see a good agreement with the relationships shown in Heymsfield et al., 2014, particularly with the subplots for the temperature range between -60 and -50 °C and -50 and -40 °C of their Figs. 6 and 7, which is the temperature range of our data. However, the analysis performed in the study of Heymsfield et al., 2014 includes the comparison of various methods, a broad range of temperatures and several campaigns, which is beyond the scope of this study. Since the extinction coefficients are already shown in the panel (c), we would not include the panel in Fig. 8 of the manuscript, if the reviewer sees no urgent need.



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