Reviewer Comments on:

"Balloon borne aerosol-cloud interaction studies (BACIS): New observational techniques to understand and quantify aerosol effects on clouds."

General Comments:

With the best will in the world, the grammar and general sentence structure in this manuscript is not amazing. I would recommend the authors conduct a detailed review into the language they have used here—particularly in the first two sections—since it was hard to interpret in places. I understand, however, that it is unfair when English is not your first language, so I leave my comment with good intentions.

This manuscript presents the results of several field campaigns conducted using a synergy of aerosol instrumentation, including balloon-based sensors and remote sensing apparatus. The authors correctly note that characterisation of aerosol cloud interactions is important and ongoing research. They also make the point that multiple instruments must be used in a field campaign to play to their respective advantages and disadvantages.

It is difficult to understand the exact purpose of this manuscript. The authors appear to focus on many different topics but not go into too much detail on each one. It would be better if the authors were clearer on whether this is for instrument validation/inter-comparison, presenting a novel data analysis technique, or presenting a dataset. A paragraph at the end of the introduction would be nice.

The authors create the narrative that this measurement campaign type is "unique", however there are many studies into atmospheric aerosol using both balloons and remote sensing apparatus (Kezoudi *et al* 2021 for example). This narrative needs to be weakened, and the relevant literature needs to be cited. I have made a few specific comments to this aim. Generally, I find the techniques used for data analysis and processing in this research more novel than the measurements themselves; if this is what the authors meant then it needs to be stressed more specifically because it was not clear to me.

In Sect. 2.1, can you detail the method by which the sensors are aspirated, and the relevant sample flow rates. Also, can you detail how you have mounted the instruments to the balloon package, and how you have ensured isokinetic flow. Also, attention to how platform-based sampling biases affect your measurements is required in this section, particularly since you have correctly pointed out in your introduction that aircraft suffer from these disadvantages too.

Generally some of the subsections under Sect. 2 can be merged. The current structure of this entire section is confusing, and much of the information is repeated. I am not entirely sure what the purpose of Sect. 2.3 is, since much of this content is also present in the introduction and other subsections of Sect. 2. Overall this section needs to be more information dense.

It would be nice to have a figure in Sect. 3 somewhere to show measurement context—that is, a map of the campaign area showing the balloon launch site, the location of remote sensing apparatus, wind direction, and relevant mesoscale parameters.

The authors conclude that the remote sensing and in-situ instruments "agree well", but this statement means nothing. The results of basic statistical tests—even a percentage difference would be better than nothing—followed by an explanation of why this means they "agree well", needs to be stated in Sect. 3 as well as the summary.

Specific Comments:

- Page 1, title. The title is misleading. It appears to either incorrectly present the paper as a review paper, or somehow claim that these are the first balloon-based aerosol measurements. You could fix this by changing it to something along the lines of:

"The results of Balloon borne Aerosol-Cloud Interaction Studies (BACIS)—a set of campaigns to understand and quantify aerosol effects on clouds."

- Page 2, line 34. An important aspect of what?
- Page 2, line 37. I struggle to see what is unique specifically regarding the measurements presented here, Kezoudi *et al* 2021. Combined balloon-based aerosol measurements with remote sensing.

- Page 2, line 44. Can you quantify the agreement and how "good" it is please? Standard deviations? Correlation coefficients?
- Page 2, line 52-53. "Paving the way for further investigations using this approach" is overly emotive language, especially considering campaigns involving similar instrumentation and platforms have been conducted before (for example A-LIFE and DETECT in the eastern Mediterranean).
- Page 3, line 65. Sentence starting "All these effects…", I'm not sure what the authors are saying here, please revise phrasing.
- Page 3, lines 80-81. Please cite some UAV examples here too since you mentioned them as a platform, for example Mamali *et al* 2018, Girdwood *et al* 2020, Girdwood *et al* 2022.
- Page 3, line 82-83. A balloon will also perturb the atmosphere while sampling. In fact, there is less information and data on balloon-based aerosol sampling artefacts than conventional aircraft. This is important to state.
- Page 6, line 133. I am unclear as to whether this instrument measures the scattering from single particles like the UCASS (smith *et al* 2019), or ensemble scattering properties, could you clarify this?
- Page 6, line 134. The acronym "FWHM" is undefined.
- Page 6, line 141. "also delivered in cps", do you mean "also conducted with the CPS? Also the acronym must be capitalised.
- Page 6, lines 141-142. I am not sure what you mean by "the sonde is passed", do you mean launched? Also, explain what "the return signal data is within 15% of the reference value" means.
- Page 9, line 216. Operated, not operational.
- Page 30, line 744. Remove "we noticed".
- Page 31, lines 771-772. I'm not convinced that this study "paves the way for future campaigns to understand aerosol-cloud process". Please remove this line or soften the concluding statement.
- Figure 5, left panel. Counts per second data is not necessary because it does not mean anything without information regarding flowrate through the instruments.
- Figure 10a. dn/dlog(D_p) is a more standard method for displaying particle size distribution data, since counts on its own doesn't really mean much.
- Figure 11a. Can you state what the box and whiskers represent? Is it mean, interquartile range, and range? If the red crosses are outliers, then there is a lot of outliers in these data, can you explain why this is?
- Figure 11b. The results shown here are near illegible, I think a line plot with bin centres on the x-axis would be better. Also a key is needed here to indicate what the different colours mean.
- Figure 12. The figure caption states that the data are from 100, 200, 300, 400, and 500 m below the cloud base but only the latter 3 are shown on the graph. You state in the text that 100 and 200 m lack enough data points for a statistically significant result, but the caption is wrong.
- Figure 12. Only 5 balloon sounding results are shown, but in Sect. 3.4 it is mentioned that 6 launches were observed with aerosol and cloud layers, why did you omit these results?

References:

Kezoudi, M., Tesche, M., Smith, H., Tsekeri, A., Baars, H., Dollner, M., Estellés, V., Bühl, J., Weinzierl, B., Ulanowski, Z., Müller, D., & Amiridis, V. (2021). Measurement report: Balloon-borne in situ profiling of Saharan dust over Cyprus with the UCASS optical particle counter. Atmospheric Chemistry and Physics, 21(9), 6781–6797. https://doi.org/10.5194/acp-21-6781-2021

Mamali, D., Marinou, E., Sciare, J., Pikridas, M., Kokkalis, P., Kottas, M., Binietoglou, I., Tsekeri, A., Keleshis, C., Engelmann, R., Baars, H., Ansmann, A., Amiridis, V., Russchenberg, H., & Biskos, G. (2018). Vertical profiles of aerosol mass concentration derived by unmanned airborne in situ and remote sensing instruments during dust events. Atmospheric Measurement Techniques, 11(5), 2897–2910. https://doi.org/10.5194/amt-11-2897-2018

Girdwood, J., Smith, H., Stanley, W., Ulanowski, Z., Stopford, C., Chemel, C., Doulgeris, K.-M., Brus, D., Campbell, D., & Mackenzie, R. (2020). Design and field campaign validation of a multi-rotor unmanned aerial vehicle and optical particle counter. Atmospheric Measurement Techniques, 13(12), 6613–6630. https://doi.org/10.5194/amt-13-6613-2020

Girdwood, J., Stanley, W., Stopford, C., & Brus, D. (2021). Simulation and Field Campaign Evaluation of an Optical Particle Counter on a Fixed-Wing UAV. Atmospheric Measurement Techniques Discussions, October, 1–26. https://doi.org/10.5194/amt-2021-275

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