**Responses to Reviewers**

We would like to thank the Reviewers for their time in reviewing the revised version of our manuscript and for the thoughtful feedback they have provided. As discussed in greater detail in our point-by-point responses below, we have incorporated your suggestions in the newly updated version of the manuscript. Compared to the previous version, the most substantial changes include:

- An overhaul of the Introduction section to convey the background and motivation for our study with a clearer story and better representation of the conclusions in prior literature.
- Breaking section 2 apart into five subsections, including a more comprehensive overview of CAMP$^2$Ex in section 2.1.
- Moving the AMPR cloud liquid water (CLW) analysis from section 3 to supplemental material. We have decided that AMPR's polarization-corrected temperatures (PCTs) should be the primary AMPR results as they are available in regions of strongest precipitation sampled, which is a key indirect indicator of convective intensity in this study. In contrast, as was previously discussed in the manuscript, AMPR's CLW retrievals fail in regions of moderate-to-high precipitation. While we had hypothesized that key trends would be observable in these results, we feel that the CLW results distract from the main point of focusing on regions of strongest sampled convection, especially since the results sections opened with the CLW analysis in the previous manuscript revision. Therefore, while we want to present the CLW results, we feel they are better suited for supplemental material with some key references made to them in the main text.
- Removing 700-hPa vertical velocity ($w_{700}$) as an environmental parameter. This was based on questions regarding the true magnitude of the $w_{700}$ values observed compared to the uncertainty in this derived product from the dropsondes. Ultimately, while interesting trends may be discernable from this product, we are less confident in it compared to the other environmental parameters and feel it would be best to exclude it from the manuscript.
- Including a bootstrapping analysis, with all results in sections 3 and 4 now reflecting mean values calculated across the 1000 runs used in this analysis.
- Giving greater attention to some of the more-inconclusive results from our study, including a general shift in the conversation throughout sections 3–5 to better convey some of these inconclusive results rather than focusing on the strongest correlations (though the latter discussions are still present in sections 3–5).
- The identification and correction of two primary coding errors made by the lead author. These errors involved cases where some of the APR-3 files were mismatched with the AMPR and HSRL2 data in a minority of the scenes examined in our study. Ultimately, while some of the values reported in the correlation analyses changed because of these corrections, the science was not greatly impacted and the overall message in our study did not change due to these corrections. This is especially true since we have now given greater focus on the general inconclusiveness indicated by many of our analyses.

Our responses to specific Reviewer comments can be found below, wherein Reviewer comments are presented in italicized font and our response immediately follows in standard font.

**Reviewer #1:**

*Review of revised manuscript "Observed impacts of aerosol concentration on maritime tropical convection within constrained environments using airborne radiometer, radar, lidar, and dropsondes" by Amiot et al.*

*Recommendation: accept after revisions*

*Overall evaluation: I think the paper has improved. Some of my comments on the observational uncertainty and interpretation of the observations (e.g., correlation versus causation) are now addressed (at least as far as I can tell). However, I claim that the introduction and motivation for the study presents an unclear (or even misleading) picture of the invigoration conundrum. In my opinion, the introduction is written from the perspective of a person who believes that the convective invigoration in polluted environments (all other factor being equal) is a proven effect. On physical grounds, the pollution-induced invigoration has little merit, especially the so-called cold invigoration that strongly depends on details of the freezing and condensate off-loading aloft (see section 2 in Grabowski and Morrison JAS 2020 and discussions in Igel and van den Heever GRL 2021 and Varble et al. ACP 2023). Below I provide several specific comments that the authors should address before the manuscript is accepted.*

We thank you very much for your review of our revised manuscript, and we have included your recommendations in the latest version as discussed in our responses below.

*Specific comments on the introduction.*

*The introduction of the pollution-induced invigoration in the third paragraph of the opening section should start with two seminal papers that initiated the discussion: Andreae et al. (Science 2004, not listed in the manuscript) and Rosenfeld et al. (Science 2008). The brief review of studies trying to prove and disprove the impact in observations and modeling should follow. However, the physical basis of the invigoration should be also brought into the picture following the discussion in the papers listed above. It would be appropriate to point out that the warm-phase invigoration depends on the finite supersaturation within cloud updrafts (because reducing supersaturation in polluted clouds increases buoyancy), with the condensation rate depending only on the updraft velocity as long as the supersaturation is equal to the quasi-equilibrium supersaturation (see section 2b in Grabowski and Morrison JAS 2020). The cold-phase invigoration critically depends on the details of the frozen precipitation off-loading aloft because the latent heating due to freezing approximately balances the weight of the liquid water carried across the melting level (see section 2a in Grabowski and Morrison as well as Igel and van den Heever and Varble et al. papers). I feel a correct motivation for the study under review is important for providing a proper context. It also reflects in my view rather mixed results discussed in the paper, perhaps because details of the physical mechanisms involved (finite supersaturations, freezing and off-loading cloud condensate aloft) are practically impossible to document in observations. However, I feel the study is an important contribution to the problem, but a proper perspective of the past research is important.*

We have revised the content and layout of the introduction (section 1) based on your suggestions and those of the other Reviewer. The updated introduction and motivation follow your suggested format/flow, including the references you've listed here and at the end of your review.

The general layout of section 1 is now:

1. Describe the purpose and importance of our study
2. Summarize the secondary indirect effect of aerosols
3. Introduce the physics behind warm- and cold-phase invigoration
4. List some example studies whose results support these invigoration mechanisms
5. List some example studies whose results counter these invigoration mechanisms
6. Use the mixed results from these studies to springboard our study and hypotheses, including more in-depth discussions about the relationships between convective intensity and the microwave remote sensing signatures we've examined

*Specific detailed comments.*

*1. L. 44: What do you mean by "environmental contexts". Please explain.*

This phrase was meant to indicate that we would consider the environmental conditions around observed aerosol and convective metrics when discussing the implications of possible aerosol-cloud interactions within a given scene. We have modified this wording on line 44 to be "… while considering adjacent environmental conditions."

*2. L. 65. The warm-phase invigoration is not defined. L. 91: the same for cold-phase invigoration.*

These concepts are now defined in the introduction on lines 61–65.

*3. When you bring Fan et al. Science paper, it would be appropriate to bring the rebuttal of their findings in Öktem et al. (JAS 2023). Just to show that the science is not as obvious as Fan et al. imply.*

We have added the study by Öktem et al., (2023), including its contradiction to the results of Fan et al., (2018) on lines 101–102.

*4. L. 74: "Numerous other modeling studies…". L. 92: "…despite numerous studies supporting the idea…". Such statements make me believe that the authors do believe in the invigoration, and do not seriously consider those who base their convictions on physical processes and object simple explanations of the "observed" impact of pollution on convection. What about studies that provide picture consistent with theoretical considerations as in Grabowski and Morrison papers or apply more careful analysis of observations (e.g., Varble JAS 2018, Öktem et al. JAS 2023)?*

We appreciate the Reviewer pointing this out, as our wording was meant to indicate the prevalence of literature that support the aerosol invigoration of convection. We have modified this wording to present the differing conclusions of prior studies more clearly. Specifically, we now discuss (lines 75–92) how some studies have proposed and/or supported the idea of aerosol invigoration of convection while balancing this with a similar-length discussion (lines 93–114) of studies whose conclusions generally don't support the aerosol invigoration of convection, including the manuscripts you've suggested.

*5. K-index, LR, and many other acronyms. All those should be defined once first used in the text. The reference to Table 1 that explains those acronyms in more detail should be included when these are introduced. I have to admit that, for someone not familiar with airborne instrumentation, the number of acronyms used in the paper is frustrating. As an example, QC for "quality control" is used just 4 times, and I do not think the acronym is needed.*

We have now used more-general descriptions and terminology when introducing our hypotheses on lines 115–156, and we return to these hypotheses at the end of section 2 (i.e., lines 388–392) to list specific expectations for each convective and environmental parameter after defining their acronyms throughout section 2 and describing them in greater detail therein. We have also removed several acronyms from the updated manuscript, now spelling out their full names during their relatively infrequent usage, including: cloud condensation nuclei (CCN), hydrometeor diameter (D), equilibrium level (EL), level of free convection (LFC), noise-equivalent differential temperature (NEDT), quality control (QC), relative humidity (RH), and science flight (SF).

*6. L. 136: The reference to Kretschmer et al. is not needed. That paper is from a different field and not really explaining the difference between correlation and causality. The fact that correlation does not imply causality should be obvious in its own right, and it is recognized by some papers the authors cite (e.g., see the abstract in Lin et al. JGR 2006 already cited in the manuscript).*

We have removed the reference to Kretschmer et al. (2017) from the manuscript as you've suggested, and we've referenced Lin et al. (2006) on line 148 when noting differences between correlation and causality.

*7. Text references to entries in the Table 1 can be improved. For instance, L.288: I suggest "…AVAPS parameters marked as "environmental" in Table 1 were employed…". L. 297: "…marked as "aerosol" in Table 1".*

We have provided additional details when referencing Table 1 in the manuscript text, especially around lines 352–356.

*8. L. 329: "…result was unexpected…". Why? See my comments above.*

We have removed this statement from the manuscript to coincide with the modifications made to our introduction section.

*References not cited in the manuscript:*

*Andreae, M. O., Rosenfeld, D., Artaxo, P., Costa, A. A., Frank, G. P., Longo, K. M., and Silva-Dias, M. A.: Smoking rain clouds over the Amazon, Science, 303, 1337–1342, https://doi.org/10.1126/science.1092779, 2004.*

*Öktem, R., D. M. Romps, and A. C. Varble, 2023: No Warm-Phase Invigoration of Convection Detected during GoAmazon. J. Atmos. Sci., 80, 2345–2364, https://doi.org/10.1175/JAS-D-22-0241.1.*

*Varble, A., 2018: Erroneous Attribution of Deep Convective Invigoration to Aerosol Concentration. J. Atmos. Sci., 75, 1351–1368, https://doi.org/10.1175/JAS-D-17-0217.1.*

*Signed: W. Grabowski.*

**Reviewer #2:**

*2nd Review of Observed impacts of aerosol concentration on maritime tropical convection within constrained environments using airborne radiometer, radar, lidar, and dropsondes by Amiot et al. (2024).*

*I commend the authors for making significant methodological improvements in their manuscript. Indeed, it appears that these changes had a substantial impact on some of the correlations and I believe that the results should be more robust now. Nevertheless, I still find some major problems with the manuscript and I suggest to return the manuscript to the authors for* ***major revisions****.*

*Please note that line numbers are based on the manuscript without tracked changes.*

We thank you very much for your review of our revised manuscript, and we have incorporated your suggestions into the updated version as noted in our responses below.

***General comments***

*1. My most major concern regards the overall interpretation of the results. Despite the more robust methodological approach, there are still many unexpected results. Furthermore, if one investigates correlations for such a large number of variables one is bound to find a correlation somewhere. What about all the non-correlated examples? There is little to no discussion about them. Yes, there are some potentially interesting correlations that the authors can report, but I still feel that these correlations are strongly influenced by one or two outliers. Take these points away and the correlation disappears. Visually it seems that correlations could be entirely different in most cases if just a few points are changed. Are the outliers really related to aerosol-cloud interactions or is there something entirely different going on? To me the authors have not sufficiently demonstrated that different processes can be ruled out (see for example comment 4).*

*In fact, in Figures 5 and 7 there appears to be a general trend that for larger sample sizes correlations are smaller. Below I also show an example from Figure 7. For 850-500 LR there is a strong correlation in the medium bin, but for the 700-500 LR there is strong correlation in the high and low bins. It seems likely that this happens because of just a few points shifting between bins.*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 700-500 LR | **0.78 (9)** | **0.74 (9)** | **0.82 (9)** | **0.83 (9)** | **0.79 (9)** | 0.69 (9) | H |
| | 0.09 (10) | 0.04 (10) | 0.16 (10) | 0.17 (10) | 0.12 (10) | 0.16 (10) | M |
| | **0.90 (8)** | **0.80 (8)** | **0.96 (7)** | **0.96 (8)** | **0.82 (9)** | **0.92 (9)** | L |
| 850-500 LR | 0.28 (9) | 0.27 (9) | 0.41 (9) | 0.43 (9) | 0.45 (9) | 0.53 (9) | H |
| | **0.83 (9)** | **0.81 (9)** | **0.84 (9)** | **0.84 (9)** | **0.79 (9)** | **0.72 (9)** | M |
| | 0.07 (9) | -0.04 (9) | 0.07 (8) | 0.01 (9) | 0.06 (10) | 0.07 (10) | L |

*To me personally the results remain rather inconclusive. Maybe the authors can rethink their interpretation of the data by emphasizing inconclusiveness due to limited samples and many unexpected trends. I do believe that such results should be reported as well. The way the results are currently reported I find it hard to justify publication in ACP. We have seen in previous literature that sometimes there are correlations between convective parameters and aerosol measurements. Is it really surprising to find this in a new dataset when looking at 100s of potential correlations?*

We have significantly changed sections 3–5 in the updated manuscript, including a complete overhaul of sections 3 and 4, in response to the concerns you have raised and to reflect the updated results after correcting the coding errors listed on page 1. Given the changes to the correlation tables, in addition to the points you've raised about the results in general, we now provide much greater focus on the general inconclusive nature of the results in our discussions throughout sections 3–5 and in the abstract. In addition to noting and discussing the presence of numerous weak and/or statistically insignificant correlations resulting from our analyses, we specifically note and highlight some of the more-unexpected trends in our discussions of the scatterplots. Further, Fig. 8a is devoted to providing an in-depth examination of an aerosol-convective comparison wherein the correlations were weak and statistically insignificant for all three environmental bins, whereas our previous manuscript versions had solely focused on producing scatterplots to include some of the strongest positive correlations with high statistical significance. We do still highlight some of the strongest and/or most statistically significant correlations in the scatterplots, but we take greater care to present these as potentially interesting trends that may be worthy of future analysis while acknowledging that they appear among a greater abundance of weaker and less statistically significant correlations in our results.

Regarding the figure segment you've included in your review, we wanted to mention that the effect of "a few points shifting between bins" cannot be ascertained by comparing the 850–500-hPa LR and 700–500-hPa LR values in (the former) Fig. 7 since these represent two different, albeit similar, environmental conditions. To examine the effects of data points shifting between the low-medium-high bins, the sensitivity tests in (the former) Fig. S10 must be examined, wherein most of the correlation trends did not change significantly. However, in agreement with your point, there is indeed sensitivity amongst the correlation values depending on how many data points fall into each bin and what the low-medium and medium-high thresholds are. There are also cases where the correlations do, ultimately, change considerably among the sensitivity tests as you've noted, especially for very small samples (e.g., the high category of 700–500-hPa LR, which always contained fewer than 10 data points in the sensitivity tests shown in the previous manuscript version).

*2. Maybe a bootstrapping approach could help investigate the issue of outliers. Randomly remove 10 – 20% of the data points many times and recalculate correlations to achieve a mean correlation. For the small sample sizes this might need to be limited to unique realizations of the dataset. However, I fear that overall correlations would become much weaker.*

This is an interesting idea. In the updated manuscript, we have utilized a bootstrapping approach for all correlations and p-values investigated in our study, wherein 10% of the paired convective-aerosol data array elements (rounded up to the nearest whole integer) were withheld. A new correlation coefficient and p-value were calculated using these "reduced" arrays, and this process was repeated 1000 times for each paired convective-aerosol data array before the resulting 1000 correlation coefficients and p-values were each averaged. This procedure has been added to the manuscript on lines 362–372. In addition, as noted on lines 367–368, the values in Figs. 2, 4, 6, and 7 now reflect these mean correlation coefficient values, the associated mean p-values, and the mean number of data points considered during this bootstrapping approach for each comparison.

Most of these newly calculated mean correlation coefficients and p-values differed very little compared to the previous non-bootstrapped analysis. An example of these differences for the AMPR CLW and $\text{Pixels}_{\text{Ku}}$ analyses is provided in Fig. R1 on the next page. Most correlations were within 0.01 of their previous values in each figure. There were some slight (i.e., ~0.01–0.02) increases in the associated p-values that resulted from averaging across the 1000 comparisons, which appear a bit more striking in the figures given the color/shading gradient in the selected colorbar. However, the "most-significant" correlations with a p-value < 0.01 typically retained a fairly low p-value near 0.01–0.03. As you noted, the bootstrapping approach posed some challenges for small array sizes, namely that any comparisons with a sample size < 10 were left unchanged since removing 10% of the dataset and rounding up to the nearest whole integer yielded the same sample size. The largest changes occurred for sample sizes of 10–15, where removing a single data point had a relatively strong impact on the calculated correlations, which matches expectations. We have added descriptions of the bootstrapping results throughout the discussions in sections 3 and 4 based on the new values in Figs. 2, 4, 6, and 7.

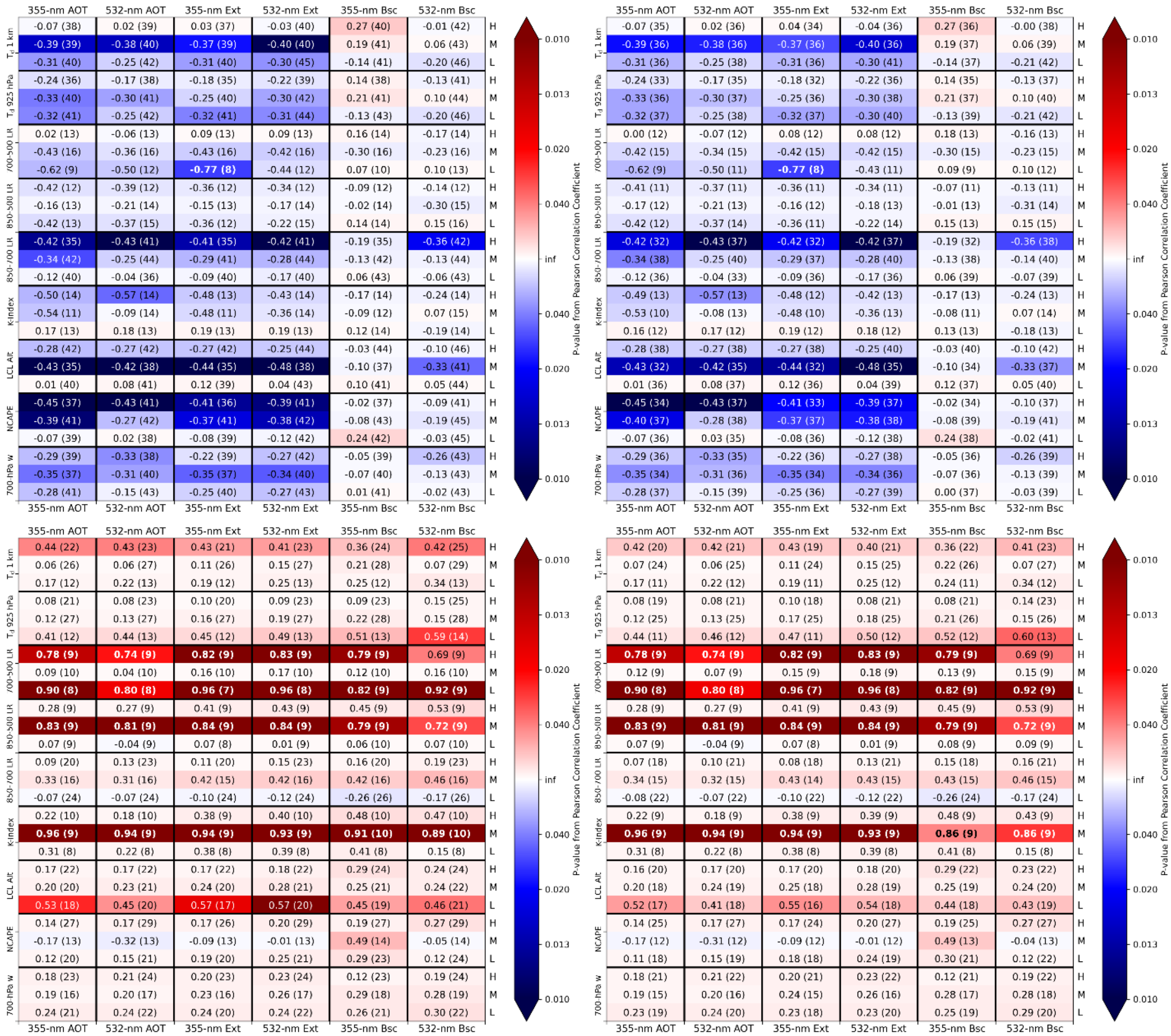

**Figure R1: Tables of Pearson correlation coefficients and their statistical significances, as in Fig. S4 of the supplemental material. Herein, the top row presents AMPR CLW and the bottom row presents Pixels$_{\mathbf{Ku}}$ prior to (left) and after (right) applying the bootstrapping approach. These figures are based on the previous version of the manuscript and before any adjustments were made to the Python codes as outlined on page 1 of this document.**

*3. The introduction has improved significantly in terms of the covered literature. However, I still feel it is not very engaging, mostly it is just listing previous research without telling a story that motivates the research. Still the paragraphs starting in lines 42 and 103 seem out of place to me. One part that is missing is why we care about aerosol impacts on convection. It is interesting that there are interactions but what are the potential consequences (radiation, precipitation, etc.)? I think that is what the introduction should start with.*

We have made additional changes to the introduction (section 1) in the updated manuscript based on your suggestions. The first paragraph of the introduction now opens with the purpose and a note about using CAMP$^2$Ex data, pointing the reader to section 2 for a more-thorough overview of the campaign, before moving into a description of some consequences of the aerosol impacts on convection from a meteorological perspective and the broader societal impacts. The paragraphs that began on lines 42 and 103 in the previous manuscript version have had much of their content moved to section 2. In addition, following the suggestions of the other Reviewer, we have modified the introduction to provide more of a comprehensive overview of different results from prior literature and have reworked several paragraphs to create a more cohesive narrative as motivation for our study.

The general layout of section 1 is now:

1. Describe the purpose and importance of our study
2. Summarize the secondary indirect effect of aerosols
3. Introduce the physics behind warm- and cold-phase invigoration
4. List some example studies whose results support these invigoration mechanisms
5. List some example studies whose results counter these invigoration mechanisms
6. Use the mixed results from these studies to springboard our study and hypotheses, including more in-depth discussions about the relationships between convective intensity and the microwave remote sensing signatures we've examined

*4. I am unsatisfied with the answer to my previous comment 4 about different convective regimes. I do believe that these can significantly impact results since development mechanisms will differ between types of convection. The authors mentioned a squall line. More organized convection might have developed 100s of km away in a different aerosol and thermodynamic environment. Maybe some shallow cumulus clouds could be invigorated compared to other shallow cumulus clouds, but we cannot really see this because all shallow cumulus will appear as weak convection compared to deeper cumulus. Just to name a couple of problems. In essence, this introduces a lot of noise to the results which might be causing some of the outliers that appear to be causing many of the trends.*

We have performed an analysis where we have separated the observed clouds into two different classes, stratus and cumulus, throughout CAMP$^2$Ex and re-ran our analyses on these two groups of clouds separately. When masking each column of APR-3 data according to these cloud classes, we used the following threshold values:

- Stratus: Ka-band 0-dBZ $Z_H$ contour extended vertically 1.98 km or less in the column
- Cumulus: Ka-band 0-dBZ $Z_H$ contour extended vertically 2.01 km or more in the column

These specific heights for the $Z_H$ contours were due to the 30-m gate spacing used in the APR-3 dataset. Likewise, we stratified the AMPR data according to:

- Stratus: CLW < 0.2 kg $m^{-2}$ in the column
- Cumulus: CLW ≥ 0.2 kg $m^{-2}$ in the column

Data columns wherein these conditions were not met were masked in their respective analysis. It should be noted that entire scenes were not necessarily masked, just the columns that were not associated with the cloud type of interest for the given analysis. We recognize that these values may not perfectly represent the clouds that would fall into each of these groups, but we found that they did a decent job of stratifying the datasets into two groups wherein a fairly significant number of correlations could be performed, especially since the bootstrapping methods noted in comment 2 above were employed in this analysis. We originally wanted to use more cloud classes (e.g., stratus, shallow cumulus, and deeper cumulus), but the sample proved too small to stratify into these three groups while maintaining a physical explanation behind each group (i.e., the original "shallow" cumulus cloud group required including clouds > 4.5 km tall based on the Ka-band 0-dBZ $Z_H$ contour to achieve a sample size large enough for most of the correlation analyses to be performed). The results of our analyses can be found in Figs. R2–R4 below.

In general, while the aerosol-convective correlations within each environmental group did change in response to isolating these two cloud classes, most did not change by a significant amount (i.e., cases where a correlation changed from moderately negative to moderately positive). Some comparisons did indeed see a considerable change in their correlation depending on which cloud class was examined, including cases where correlations were strong and statistically significant for one class but not the other. AMPR CLW was impacted most strongly, with widespread negative correlations for the stratus clouds but not cumulus clouds. This results from the clustering of data points around 0 kg $m^{-2}$ being included in the stratus-cloud analysis but not the cumulus-cloud analysis, similar to the statement made on line 476 in the manuscript.

We have decided not to include these results in the manuscript due to the severe limitations associated with this analysis, in addition to the limited sample size and limitations of the observational analysis discussed in the manuscript. In addition to the somewhat ad hoc thresholds used to separate the stratus and cumulus classes, this analysis cannot account for many other factors, such as whether the cumulus clouds developing, mature, or dissipating and, for squall lines, what the aerosol conditions were in the region wherein they initiated. We have also not considered the vertical distribution of aerosols in our study at all, which would significantly impact this cloud stratification (e.g., how the vertical aerosol distribution aligned with the position of a relatively thin stratus cloud). We wanted to include these results in our response to highlight them and demonstrate that we have considered them, but that we ultimately have chosen to maintain our grouping of all clouds together in the manuscript due to the limitations and caveats associated with this analysis. However, our CLW discussion in the manuscript now includes a discussion on lines 471–479 of the impacts very thin clouds with low CLW (e.g., < 1 g $m^{-2}$) have on the CLW-aerosol correlations, which are now presented in the supplemental material as mentioned on page 1.

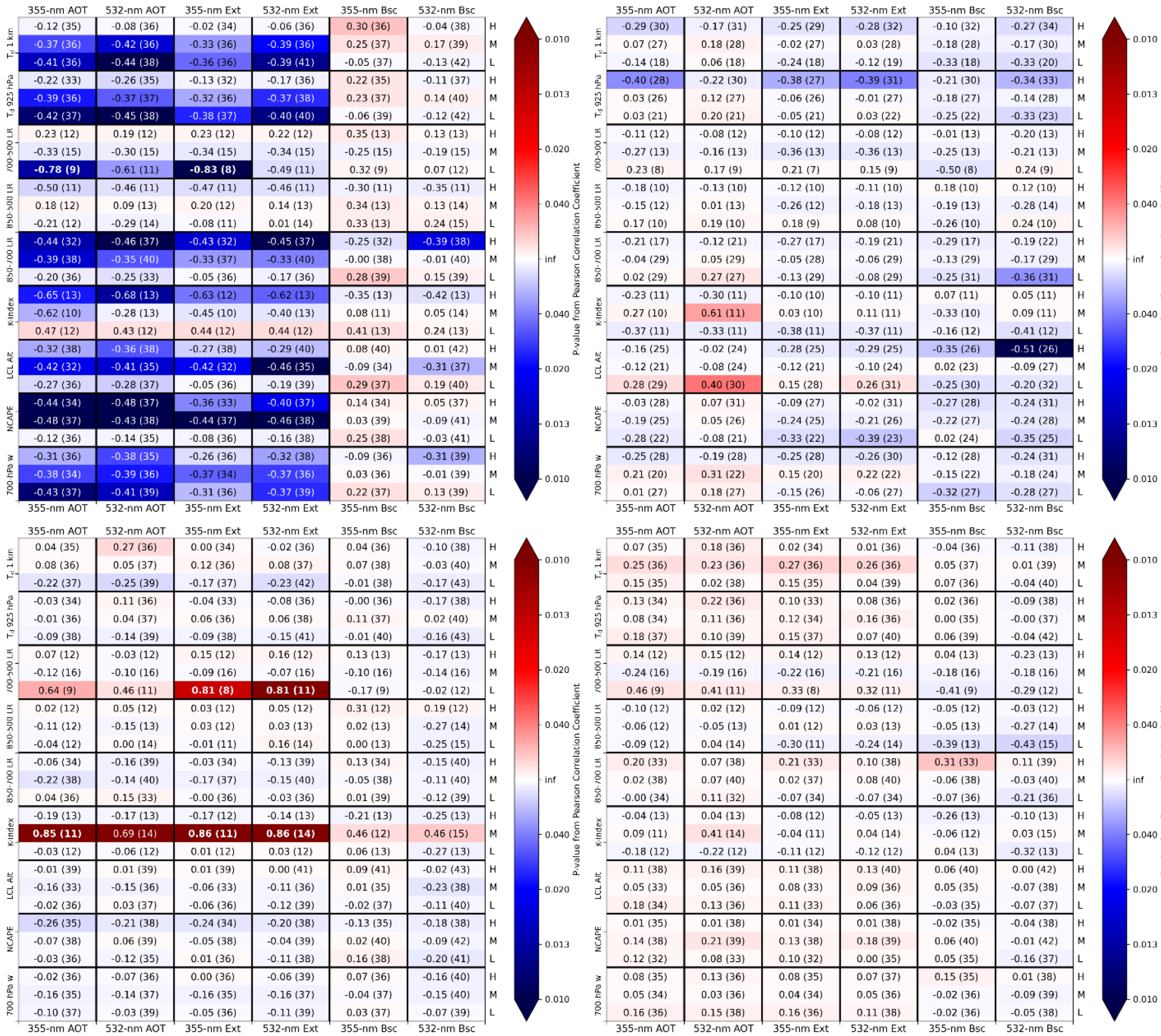


**Figure R2: Tables of Pearson correlation coefficients and their statistical significances, as in Fig. S4 of the supplemental material. Herein, the top row presents AMPR CLW and the bottom row presents $PCT_{19}$ for the analysis of stratus clouds (left) and cumulus clouds (right), applying the cloud-type thresholds and bootstrapping approach discussed above. These figures are based on a semi-updated version of the manuscript after applying adjustments to the Python code outlined on page 1 of this document.**

| | | 355-nm AOT | 532-nm AOT | 355-nm Ext | 532-nm Ext | 355-nm Bsc | 532-nm Bsc |
|---|---|---|---|---|---|---|---|
| $T_d$ 1 km | H | 0.06 (18) | 0.06 (18) | 0.03 (18) | 0.09 (18) | 0.08 (20) | 0.23 (20) |
| | M | 0.15 (18) | 0.29 (18) | 0.09 (18) | 0.05 (18) | 0.15 (19) | 0.11 (21) |
| | L | 0.22 (9) | 0.01 (10) | 0.35 (9) | 0.19 (10) | 0.29 (9) | 0.31 (10) |
| $T_d$ 925 hPa | H | 0.09 (17) | 0.10 (18) | 0.04 (16) | 0.11 (18) | 0.10 (18) | 0.23 (19) |
| | M | -0.06 (17) | 0.18 (18) | -0.09 (17) | -0.04 (18) | 0.05 (18) | 0.07 (19) |
| | L | 0.34 (11) | 0.10 (12) | 0.43 (11) | 0.26 (12) | 0.32 (12) | 0.31 (13) |
| 700-500 LR | H | 0.20 (9) | 0.12 (9) | 0.36 (9) | 0.37 (9) | 0.37 (9) | 0.33 (9) |
| | M | 0.25 (8) | 0.36 (8) | -0.02 (8) | -0.01 (8) | -0.63 (8) | -0.09 (8) |
| | L | 0.06 (7) | 0.22 (7) | -0.08 (6) | -0.27 (7) | -0.14 (8) | 0.41 (8) |
| 850-500 LR | H | 0.24 (8) | 0.63 (8) | 0.28 (8) | 0.33 (8) | 0.29 (8) | 0.42 (8) |
| | M | 0.01 (9) | 0.05 (9) | 0.06 (9) | 0.05 (9) | 0.19 (9) | 0.24 (9) |
| | L | 0.61 (7) | 0.59 (7) | 0.60 (6) | 0.19 (7) | -0.22 (8) | 0.48 (8) |
| 850-700 LR | H | -0.05 (12) | 0.05 (15) | -0.11 (12) | -0.13 (15) | -0.25 (12) | -0.08 (16) |
| | M | -0.09 (14) | -0.12 (14) | -0.04 (13) | -0.20 (14) | 0.41 (14) | 0.41 (14) |
| | L | 0.12 (18) | 0.10 (18) | 0.15 (18) | 0.21 (18) | 0.20 (20) | 0.21 (20) |
| K-Index | H | 0.59 (9) | **0.71 (9)** | 0.23 (9) | -0.33 (9) | -0.31 (9) | 0.32 (9) |
| | M | -0.22 (7) | -0.23 (7) | -0.05 (7) | -0.05 (7) | 0.49 (8) | 0.55 (8) |
| | L | -0.00 (7) | 0.02 (7) | 0.11 (7) | 0.16 (7) | 0.26 (7) | 0.07 (7) |
| LCL Alt | H | 0.15 (17) | 0.05 (17) | 0.21 (17) | 0.16 (17) | 0.30 (18) | 0.26 (18) |
| | M | 0.05 (12) | 0.14 (14) | 0.10 (12) | 0.23 (14) | 0.23 (13) | 0.20 (16) |
| | L | -0.01 (16) | 0.20 (17) | -0.24 (15) | -0.35 (17) | -0.46 (17) | -0.07 (18) |
| NCAPE | H | -0.04 (19) | 0.00 (20) | -0.06 (18) | -0.02 (20) | 0.06 (19) | 0.14 (20) |
| | M | 0.15 (15) | 0.01 (16) | 0.26 (15) | 0.17 (16) | 0.12 (16) | 0.22 (18) |
| | L | 0.44 (10) | 0.51 (11) | 0.39 (10) | 0.38 (11) | 0.48 (13) | 0.46 (14) |
| 700-hPa w | H | 0.03 (16) | 0.10 (17) | 0.07 (16) | 0.08 (17) | 0.07 (16) | 0.01 (18) |
| | M | -0.08 (12) | -0.13 (13) | 0.01 (12) | -0.03 (13) | 0.25 (14) | 0.32 (15) |
| | L | 0.48 (17) | 0.40 (18) | 0.42 (16) | 0.35 (18) | 0.08 (17) | 0.33 (18) |

| | | 355-nm AOT | 532-nm AOT | 355-nm Ext | 532-nm Ext | 355-nm Bsc | 532-nm Bsc |
|---|---|---|---|---|---|---|---|
| $T_d$ 1 km | H | 0.38 (17) | 0.44 (17) | 0.34 (16) | 0.35 (17) | 0.43 (18) | 0.50 (18) |
| | M | 0.45 (17) | 0.46 (18) | 0.24 (17) | 0.39 (18) | -0.30 (18) | -0.24 (20) |
| | L | 0.50 (10) | 0.28 (12) | 0.44 (10) | 0.38 (12) | 0.02 (10) | 0.09 (12) |
| $T_d$ 925 hPa | H | 0.27 (14) | 0.26 (15) | 0.22 (13) | 0.22 (15) | 0.29 (16) | 0.36 (17) |
| | M | 0.47 (17) | 0.44 (18) | 0.31 (17) | 0.41 (18) | -0.32 (18) | -0.15 (19) |
| | L | 0.53 (13) | 0.37 (14) | 0.46 (13) | 0.43 (14) | 0.09 (14) | 0.07 (15) |
| 700-500 LR | H | 0.16 (8) | 0.16 (8) | 0.22 (8) | 0.23 (8) | 0.14 (8) | 0.31 (8) |
| | M | 0.05 (9) | 0.15 (9) | -0.04 (9) | -0.04 (9) | -0.10 (9) | 0.06 (9) |
| | L | 0.56 (8) | 0.43 (8) | 0.65 (7) | **0.71 (8)** | **0.88 (9)** | **0.73 (9)** |
| 850-500 LR | H | 0.15 (8) | 0.26 (8) | 0.15 (8) | 0.16 (8) | 0.10 (8) | 0.27 (8) |
| | M | 0.42 (9) | 0.40 (9) | 0.39 (9) | 0.38 (9) | 0.35 (9) | 0.43 (9) |
| | L | 0.21 (8) | 0.16 (8) | 0.28 (7) | 0.27 (8) | 0.24 (9) | 0.53 (9) |
| 850-700 LR | H | 0.38 (12) | 0.27 (15) | 0.43 (12) | 0.35 (15) | 0.62 (12) | 0.22 (16) |
| | M | 0.30 (15) | 0.27 (15) | 0.21 (14) | 0.20 (15) | 0.06 (15) | 0.07 (15) |
| | L | 0.51 (17) | 0.49 (17) | 0.30 (17) | 0.43 (17) | -0.29 (18) | -0.23 (18) |
| K-Index | H | 0.32 (9) | 0.36 (9) | 0.35 (9) | 0.39 (9) | 0.45 (9) | 0.46 (9) |
| | M | 0.30 (8) | 0.33 (8) | 0.30 (8) | 0.28 (8) | 0.51 (9) | 0.54 (9) |
| | L | -0.18 (7) | -0.19 (7) | -0.15 (7) | -0.14 (7) | -0.13 (7) | -0.13 (7) |
| LCL Alt | H | 0.31 (17) | 0.24 (17) | 0.25 (17) | 0.20 (17) | 0.04 (18) | 0.04 (18) |
| | M | 0.31 (11) | 0.40 (13) | 0.36 (11) | 0.37 (13) | 0.48 (12) | 0.35 (15) |
| | L | 0.43 (16) | 0.53 (17) | 0.10 (15) | 0.36 (17) | -0.43 (17) | -0.40 (18) |
| NCAPE | H | 0.44 (20) | 0.55 (21) | 0.26 (19) | 0.40 (21) | -0.34 (20) | -0.28 (21) |
| | M | 0.10 (12) | 0.06 (13) | 0.12 (12) | 0.10 (13) | 0.05 (13) | 0.08 (15) |
| | L | **0.79 (11)** | 0.55 (12) | 0.62 (11) | 0.59 (12) | 0.37 (14) | 0.67 (15) |
| 700-hPa w | H | 0.13 (15) | 0.08 (16) | 0.12 (15) | 0.09 (16) | 0.04 (15) | 0.05 (17) |
| | M | 0.35 (12) | 0.19 (13) | 0.39 (12) | 0.35 (13) | 0.18 (14) | 0.24 (15) |
| | L | 0.54 (17) | 0.60 (18) | 0.26 (16) | 0.46 (18) | -0.36 (17) | -0.34 (18) |

| | | 355-nm AOT | 532-nm AOT | 355-nm Ext | 532-nm Ext | 355-nm Bsc | 532-nm Bsc |
|---|---|---|---|---|---|---|---|
| $T_d$ 1 km | H | -0.41 (20) | -0.33 (20) | -0.47 (19) | -0.45 (20) | -0.36 (22) | -0.35 (22) |
| | M | -0.15 (18) | -0.08 (19) | -0.20 (18) | -0.22 (19) | 0.43 (20) | 0.11 (21) |
| | L | 0.02 (10) | 0.07 (11) | 0.06 (10) | -0.04 (11) | -0.04 (10) | -0.14 (11) |
| $T_d$ 925 hPa | H | -0.32 (18) | -0.34 (18) | -0.34 (17) | -0.34 (18) | -0.16 (19) | -0.24 (20) |
| | M | -0.27 (18) | -0.11 (18) | -0.33 (18) | -0.34 (18) | 0.22 (19) | -0.06 (19) |
| | L | 0.10 (13) | 0.09 (14) | 0.15 (13) | 0.02 (14) | 0.05 (14) | -0.03 (15) |
| 700-500 LR | H | -0.30 (10) | -0.39 (10) | -0.22 (10) | -0.21 (10) | 0.04 (10) | -0.18 (10) |
| | M | -0.23 (9) | -0.18 (9) | -0.29 (9) | -0.28 (9) | -0.42 (9) | -0.31 (9) |
| | L | -0.29 (8) | -0.27 (8) | -0.33 (7) | -0.36 (8) | -0.11 (9) | -0.05 (9) |
| 850-500 LR | H | -0.25 (9) | -0.17 (9) | -0.29 (9) | -0.29 (9) | -0.18 (9) | -0.28 (9) |
| | M | -0.53 (11) | -0.56 (11) | -0.46 (11) | -0.45 (11) | -0.28 (11) | -0.41 (11) |
| | L | 0.47 (7) | 0.45 (7) | 0.48 (6) | 0.21 (7) | -0.13 (8) | 0.52 (8) |
| 850-700 LR | H | -0.29 (13) | -0.27 (15) | -0.35 (13) | -0.42 (15) | -0.47 (13) | -0.42 (15) |
| | M | -0.18 (16) | 0.03 (16) | -0.30 (15) | -0.23 (16) | -0.12 (16) | -0.16 (16) |
| | L | -0.14 (20) | -0.07 (20) | -0.08 (20) | -0.08 (20) | -0.11 (22) | -0.10 (22) |
| K-Index | H | -0.08 (10) | 0.09 (10) | -0.30 (9) | -0.39 (10) | -0.55 (10) | -0.32 (10) |
| | M | -0.38 (8) | -0.40 (8) | -0.33 (8) | -0.33 (8) | -0.01 (9) | 0.03 (9) |
| | L | -0.15 (9) | -0.13 (9) | -0.11 (9) | -0.09 (9) | -0.09 (9) | -0.09 (9) |
| LCL Alt | H | -0.09 (18) | -0.04 (18) | -0.04 (18) | -0.04 (18) | 0.20 (20) | 0.02 (20) |
| | M | -0.46 (14) | -0.32 (15) | -0.52 (14) | -0.52 (15) | -0.41 (15) | -0.60 (16) |
| | L | -0.09 (17) | 0.01 (18) | -0.16 (16) | -0.25 (18) | -0.35 (18) | -0.17 (18) |
| NCAPE | H | -0.53 (22) | -0.52 (23) | -0.57 (21) | -0.53 (23) | -0.40 (22) | -0.45 (23) |
| | M | -0.00 (15) | 0.10 (15) | -0.04 (15) | -0.06 (15) | -0.12 (16) | -0.08 (16) |
| | L | 0.37 (12) | 0.30 (13) | 0.31 (12) | 0.13 (13) | **0.70 (15)** | 0.35 (16) |
| 700-hPa w | H | -0.33 (18) | -0.29 (18) | -0.30 (18) | -0.32 (18) | -0.34 (18) | -0.40 (18) |
| | M | -0.26 (14) | -0.09 (14) | -0.33 (14) | -0.27 (14) | -0.16 (16) | -0.16 (16) |
| | L | -0.02 (18) | 0.08 (18) | -0.04 (17) | -0.15 (18) | 0.00 (18) | -0.11 (18) |

| | | 355-nm AOT | 532-nm AOT | 355-nm Ext | 532-nm Ext | 355-nm Bsc | 532-nm Bsc |
|---|---|---|---|---|---|---|---|
| $T_d$ 1 km | H | -0.13 (17) | -0.02 (17) | -0.07 (16) | -0.09 (17) | 0.21 (18) | 0.01 (18) |
| | M | -0.26 (17) | -0.15 (18) | -0.31 (17) | -0.07 (18) | 0.04 (18) | -0.18 (19) |
| | L | -0.54 (10) | -0.55 (11) | -0.35 (10) | -0.44 (11) | 0.47 (10) | 0.32 (11) |
| $T_d$ 925 hPa | H | -0.07 (14) | -0.24 (15) | 0.04 (13) | -0.11 (15) | 0.34 (16) | -0.09 (17) |
| | M | -0.23 (17) | -0.11 (17) | -0.23 (17) | -0.06 (17) | 0.05 (18) | -0.13 (18) |
| | L | -0.55 (13) | -0.53 (14) | -0.39 (13) | -0.46 (14) | 0.42 (14) | 0.26 (15) |
| 700-500 LR | H | -0.23 (8) | -0.31 (8) | -0.18 (8) | -0.18 (8) | 0.29 (8) | 0.02 (8) |
| | M | -0.34 (9) | -0.35 (9) | -0.33 (9) | -0.33 (9) | -0.31 (9) | -0.37 (9) |
| | L | -0.42 (8) | -0.54 (8) | -0.34 (7) | -0.20 (8) | 0.33 (9) | -0.27 (9) |
| 850-500 LR | H | -0.21 (8) | -0.33 (8) | -0.16 (8) | -0.16 (8) | 0.28 (8) | 0.03 (8) |
| | M | -0.44 (9) | -0.42 (9) | -0.44 (9) | -0.43 (9) | -0.32 (9) | -0.41 (9) |
| | L | -0.68 (8) | **-0.72 (8)** | -0.51 (7) | 0.13 (8) | **0.80 (9)** | -0.21 (9) |
| 850-700 LR | H | -0.44 (12) | -0.60 (14) | -0.33 (12) | -0.25 (14) | 0.22 (12) | -0.41 (14) |
| | M | -0.50 (15) | -0.59 (15) | -0.33 (14) | -0.46 (15) | 0.57 (15) | 0.49 (15) |
| | L | 0.31 (17) | 0.34 (17) | 0.31 (17) | 0.31 (17) | 0.02 (18) | -0.04 (18) |
| K-Index | H | -0.38 (9) | -0.51 (9) | -0.25 (9) | -0.03 (9) | 0.28 (9) | -0.32 (9) |
| | M | -0.22 (8) | -0.12 (8) | -0.27 (8) | -0.29 (8) | -0.41 (9) | -0.45 (9) |
| | L | -0.35 (7) | -0.37 (7) | -0.35 (7) | -0.37 (7) | -0.28 (7) | -0.41 (7) |
| LCL Alt | H | -0.19 (17) | -0.57 (17) | 0.02 (17) | -0.17 (17) | **0.75 (18)** | 0.64 (18) |
| | M | -0.25 (11) | -0.08 (12) | -0.20 (11) | -0.21 (12) | 0.25 (12) | -0.17 (13) |
| | L | -0.23 (16) | -0.11 (17) | -0.30 (15) | -0.05 (17) | -0.11 (17) | -0.25 (18) |
| NCAPE | H | -0.19 (20) | -0.16 (21) | -0.16 (19) | -0.17 (21) | -0.02 (20) | -0.15 (21) |
| | M | -0.53 (12) | -0.41 (12) | -0.36 (12) | -0.24 (12) | 0.41 (13) | 0.16 (13) |
| | L | -0.25 (11) | -0.17 (12) | -0.13 (11) | -0.14 (12) | 0.50 (14) | 0.08 (15) |
| 700-hPa w | H | -0.24 (15) | -0.37 (16) | -0.20 (15) | -0.22 (16) | -0.02 (15) | -0.32 (16) |
| | M | -0.53 (12) | **-0.77 (12)** | -0.29 (12) | -0.48 (12) | 0.63 (14) | 0.60 (14) |
| | L | -0.17 (17) | -0.02 (18) | -0.23 (16) | -0.02 (18) | -0.03 (17) | -0.19 (18) |

**Figure R3: Tables of Pearson correlation coefficients and their statistical significances, as in Fig. S4 of the supplemental material. Herein, the top row presents $Z_{95,Ku}$ and the bottom row presents $Pixels_{Ku}$ for the analysis of stratus clouds (left) and cumulus clouds (right), applying the cloud-type thresholds and bootstrapping approach discussed above. These figures are based on a semi-updated version of the manuscript after applying adjustments to the Python code outlined on page 1 of this document.**

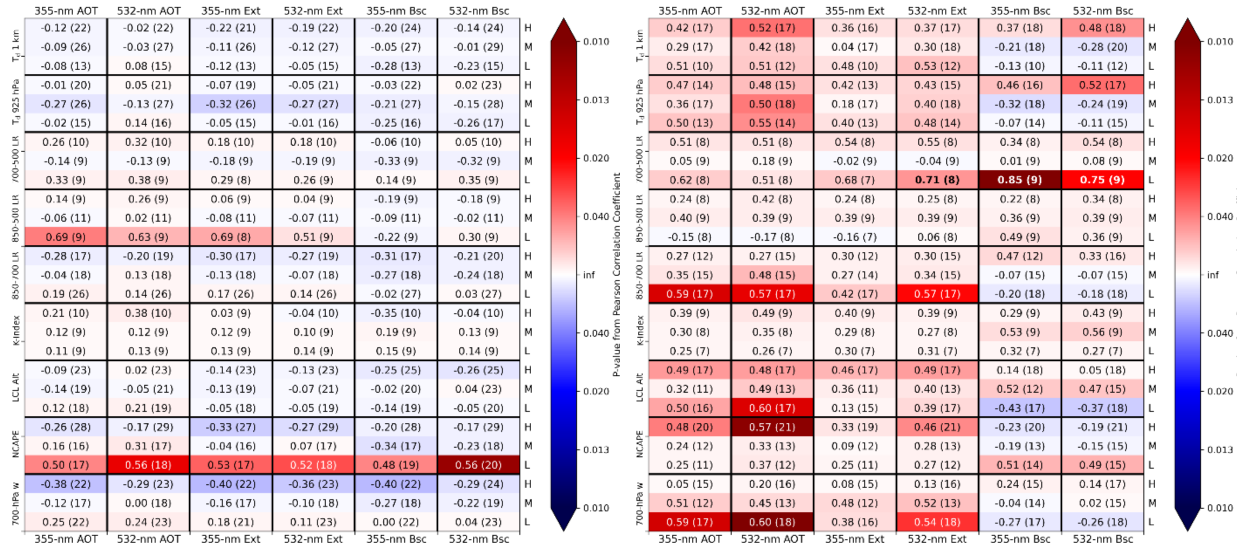


**Figure R4: Tables of Pearson correlation coefficients and their statistical significances, as in Fig. S4 of the supplemental material. Herein, DFR is presented for the analysis of stratus clouds (left) and cumulus clouds (right), applying the cloud-type thresholds and bootstrapping approach discussed above. These figures are based on a semi-updated version of the manuscript after applying adjustments to the Python code outlined on page 1 of this document.**

5. *I am also still unsatisfied with the description of the CAMP2Ex campaign. Can the authors please make a dedicated section about the campaign in the methods section? In general, the methods section would benefit from some dedicated subsections so it is easier to find specific details about the methodology.*

We have broken the methods section into subsections 2.1–2.5. Subsection 2.1 has been added to the manuscript as a subsection dedicated to describing the CAMP$^2$Ex field campaign in greater detail.

***Specific comments***

6. *57: Probably better to use 'clouds' here instead of storms.*

We have simplified the wording "convective storms" to "convection" on line 44.

7. *59: 'describes' instead of 'favors'.*

Modified as suggested.

8. *Figure 1: Excuse me if I do not fully understand the measurements, but why is there significant CLW where the radar does not observe any cloud?*

Thank you for noting this. We have identified a mismatch between the period covered by the APR-3 data in the scene figure compared to the period covered by the AMPR and HSRL2 data. Figure 1 has been updated to ensure all panels cover the same approximate 10-minute period. Due to the timing of the data reported by each instrument, including brief pauses (e.g., calibration scans), the exact times at each point along the x axis in Fig. 1 may not align completely across all panels; this can be seen, for example, by the x-axis offsets for the precipitating cloud observed around 0155 UTC. However, the start and end times are approximately the same for all three instruments, and we have included time values along the x axes for the top three panels in Fig. 1.

9. *127: These variables have not been defined.*

We have now used more-general descriptions and terminology when introducing our hypotheses on lines 115–156, and we return to these hypotheses at the end of section 2 (i.e., lines 388–392) to list specific expectations for each convective and environmental parameter after defining their acronyms throughout section 2 and describing them in greater detail therein.

*10. 157: 'absolute deviation', does this refer to CLW?*

Yes, it does; we have added this to line 198.

*11. 262: I don't quite understand why scenes longer than 11 minutes had to be masked. Couldn't you just use the 10 minutes around the dropsondes?*

This resulted from the manner in which the radar data were saved from CAMP$^2$Ex. For each science flight, the radar data were saved across several files with each file corresponding to a particular leg of the science flight. Because of this, there were cases where the 10-min scene around a given dropsonde covered more than one radar file / flight segment. The script used to match radar and dropsonde data was designed to identify the reported radar scan times nearest two times: (dropsonde launch time – 5 minutes) and (dropsonde launch time + 5 minutes). In some cases where the dropsonde was launched near the end of the time covered in a radar file, the next radar file did not start until several (i.e., > 5) minutes elapsed. The effect on our analysis was compounded by the masking we employed (e.g., aircraft maneuvers, excluding files wherein only W-band data were reported, etc.), even when stitching files together to create as seamless of a time series as possible. Because of this, the nearest radar scan to (dropsonde launch time + 5 minutes) may have actually been 10+ minutes later. Therefore, we mask scenes with times > 11 minutes as reported by this data-matching script. We similarly mask scenes where the time was < 9 minutes (e.g., a short < 10-minute flight segment between two aircraft maneuvers). We have added additional details about this data-masking method to the manuscript on lines 316–318.

*12. 347-350: Can points with significant masking be indicated somehow? Maybe use the same symbol but only show the outline for scenes where masking exceeded a certain threshold.*

We are concerned that the level of uncertainty in the masked data points is too large for their inclusion in the manuscript, even as outlined shaped within the (already fairly busy) figures. This is not solely due to native uncertainty within the retrievals, but the fact that their uncertainties become drastically higher within the data regions that were masked. In looking into your suggestion, we realized that additional details about some of the masks applied to the data in our study would be beneficial, which were outlined in Amiot, (2023) but not carried over to this manuscript. When looking at AMPR CLW in response to your question, the concern lies in the fact that a given AMPR data pixel was masked if one or more of the following were true: 1) the P-3 pitch and/or roll magnitude was ≥ 2°, since the retrievals are based on Earth incidence angle and assume level flight; 2) AMPR operated in a nadir-stare mode that was utilized for certain flight segments during CAMP$^2$Ex, for which the reliability of off-nadir pixels has not yet been evaluated; 3) the P-3 altitude was < 3 km AGL, as we noted issues with AMPR's data calibration due to insufficient cooling of its cold-load target at these lower altitudes during the science flights; 4) the given AMPR scan included at least one pixel over land, as AMPR's signal is dominated by land emission over land rather than the geophysical parameters of interest to this study; and 5) precipitation was present within the pixel based on a $T_b$ thresholding method. We also mask the 10 pixels nearest the edges of AMPR's 50-pixel swath in each scan due to residual effects of a new radome that AMPR flew with during CAMP$^2$Ex. If a given pixel was flagged solely due to precipitation, which matches the discussion on lines 347–350 in the previous manuscript version, the uncertainty associated with the retrieved CLW therein would introduce additional noise to the scatterplots in this study. Because of this, we feel it is most important to exclude all of the masked data points from the scatterplots in this manuscript.

These flags are discussed in Lang et al., (2021) and Amiot, (2023), but we have added details about them to lines 187–190 for the reader's immediate reference.

*13. 549-551: I think I understand what the authors are trying to say, but please consider rephrasing.*

We have revised this sentence on lines 595–597.

*14. 585: The following paragraph is missing some kind of discussion about why at least some of the things mentioned here were not done in this study.*

We have added a brief discussion to many of the sentences in this paragraph (i.e., starting on line 632) to explain why these are suggested for future work rather than avenues we explored in this study (all of which were ultimately partially due to time constraints of the analysis presented in the manuscript). In particular, we note how we have looked at several convective, environmental, and aerosol metrics, and are suggesting others that could potentially be interesting to examine in a similar future study. We now note our emphasis on aerosol concentration and its relation to cloud particle size distribution, in addition to our decision to focus on P-3 instrumentation in this study. Lastly, we have removed the comment about examining scenes grouped into different types of convection, as we have now examined this as discussed in our reply to comment 4 above.