Authors' comments to Anonymous Referee #1

We would like to thank the reviewer for the thorough review of our manuscript and insightful feedback. These comments have significantly improved the quality of our work. In the following sections, we present the reviewer's comments (in black), our responses (in red), and the changes made in the revised manuscript (in blue). Please note that all line numbers in our responses correspond to those in the revised manuscript.

Comments:

The authors have adequately addressed the majority of the points raised by the reviewers and improved the description of the training and generalization datasets. Additionally, the discussion on the performance of the generalization dataset is now more comprehensive, and the rationale behind tailoring the ice habit categories for the available dataset is acceptable.

However, the addition of the Appendix B (Detailed criteria for ice crystal classification) has not sufficiently resolved the concerns related to the manual labeling of ice crystal habits. In fact, the sample ice crystal images presented in the appendix have raised further issues. The problematic habit categories include Column-aggregate, Column-aged, CPC-aggregate, and CPC. Many of the "columns" in these categories appear to be needles. According to Kikuchi et al. (2013), needles are defined as "crystals shaped like needles, with tops shaped like knife-edges."

In the CPC and CPC-aggregate category many of the example crystals are missing the plate "P" section of the crystal. Following the Kikuchi diagram the crystals classified as CPC by the authors fall in the categories C1a (needle) or C1b (needle bundle). Only in the CPC-aggregate category plate growth is evident for some crystals. Following Fig. 2 of Appendix B, the classification criteria for columns and CPCs become unclear, particularly the distinction between "rectangle-based" and "hexagonal-based." It is advised that these steps are to be revised.

Thank you for your comments. We understand your concerns regarding the manual labeling of ice crystal habits. As mentioned in Section 2 of the manuscript, here we use the habit classes and datasets from Pasquier et al. (2022a, 2022b, 2023), which were published on Zenodo (https://zenodo.org/records/7402285). These published datasets include ice crystals that were manually classified into different ice categories. Although we agree with the reviewer that in some instances there may have been some misclassification of the ice crystals, an improvement to the

classified data set is not the aim of this study. The aim of this study is to introduce a novel algorithm (IceDetectNet) for classifying ice crystals down to the aggregated component level. With this in mind, we are confident that these misclassifications do not influence the ability of IceDetectNet's implementation to identify and classify ice crystals at the component level.

Following your comments, we made the following changes to the main text:

1. Column-aggregate and CPC-aggregate:
To clarify the classification of aggregated ice, we have revised the text and the caption of the Fig. B2 as follows:

L511-512
"In multi-label classification, only the largest visually identified component of the aggregate is classified, without drawing a bounding box. The classified basic habit of this component will represent the basic habit of the whole aggregate. "

Fig. B2 Caption:
A randomly selected sample of ice crystal images from each category based on the multi-label classification scheme

Thus, if some components within the aggregate do not fit into the basic habit category of aggregated ice, it is still correct based on our definition. For example, if a 'CPC' ice is aggregated with a 'Column', as long as the largest component of the aggregate is the CPC, then the label of the aggregate should still be 'CPC-aggregate'.

2. CPC and Column:
We agree that some of the CPCs are missing the "P" portion of the crystal and fall into the C1a and C1b categories in the Kikuchi diagram. Nevertheless, in our dataset, these ice crystals are classified as CPC following the argumentation of Pasquier et al. 2023, which considers the growth history of these ice particles, covering both the column and plate temperature regime (See Section 3 Results, especially Section 3.1. Observations of Columns on Capped-Column). Therefore, the classification is working correctly, even if the crystals could have been originally classified as C1a and C1b.

To address the confusion between 'CPC' and 'Column' caused by rectangular and hexagonal-based features, we have added further explanations to differentiate the ice habits more clearly, as follows:

L516-518
“Rectangular-shaped ice crystals (with 4 distinct edges) are classified as ‘columns’, whereas rectangular-shaped ice crystals with multiple branches at the end of the maximum dimension are labeled 'CPC-aged. Note, that the CPC-aged categories also include needle bundles with missing plate sections. Hexagonal crystals (with 6 distinct edges) are classified based on their aspect ratio, where a high aspect ratio indicates a 'column,' and a low aspect ratio a 'plate'.”

L96-97
“However, due to data limitations, our dataset does not capture every possible basic ice habit, such as needles and rosettes, but the existence of these ice habits is well acknowledged (Kikuchi et al., 2013).”

The reason why both 'rectangular-based' and 'hexagonal-based' could fall into the 'column' category is due to the different viewing angles of the ice particles (as all images are 2-D). Here you can see an example of each:

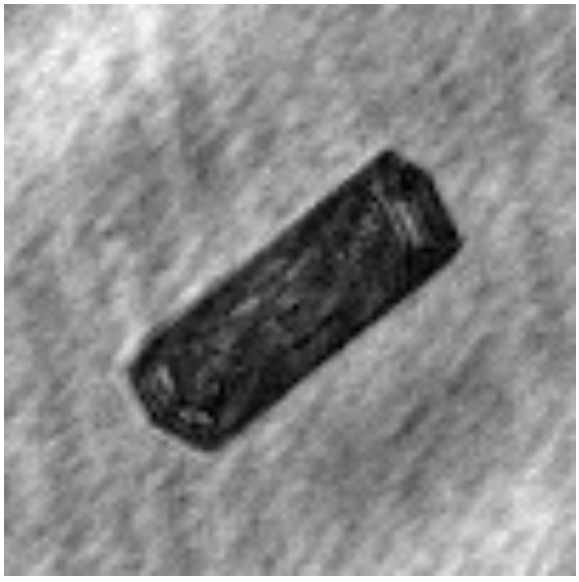

Figure 1 'Column' ice with hexagonal-based structure (6 distinct edges)

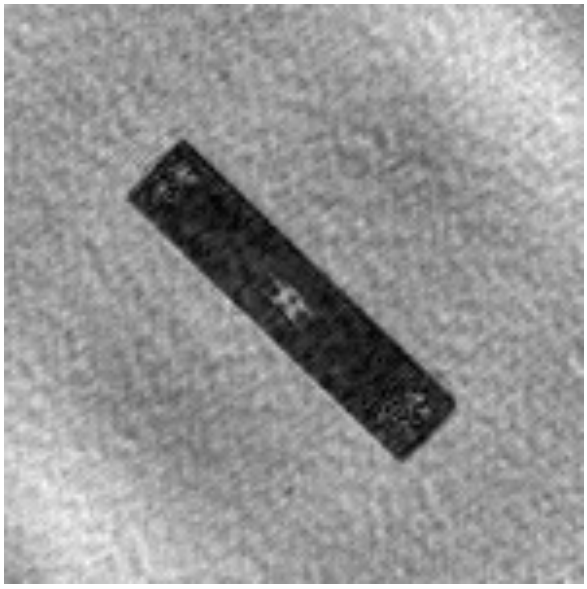

Figure 2 'Column' ice with rectangle-based structure (4 distinct edges)

We hope that these clarifications and revisions address your concerns. Thank you again for your valuable feedback, which has helped to improve the quality of our manuscript.

References

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