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Atmospheric Measurement Techniques Discussions

Interactive comment on "Unsupervised classification of snowflake images using a generative adversarial network and K-medoids classification" *by* Jussi Leinonen and Alexis Berne

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We thank Referee 2 for their comments. Please find our responses below in normal font, with the original questions quoted in *italics*.

1. Section 4: The unsupervised methodology developed to analyse the snowflake photos uses the K-medoids method instead of the K-means. These two techniques are described in section 3.4 but the author decided to use only one of them. I was wondering why the K-means is even described in the manuscript. It may be more straightforward to have only a paragraph describing the advantages using K-medoids methods with respect to the K-means and only describe the one used in the developed

unsupervised classification.

The reviewer is correct in that we do not use K-means in this paper. However, we find it is narratively useful to mention K-means first, because most readers will be more familiar with K-means, and discussing it first allows us to better specify why we choose *not* to use it.

That said, upon reviewing this section we find that there is more technical detail there than is necessary to serve the above-mentioned function. Consequently, we have shortened the discussion of K-means and edited the text such that it is clearer that the focus is on K-medoids (including changing the section title to "Classification: K-medoids").

2. Section 5: The authors describe the methodology used to classify the snowflakes using many K categories. In section 5.2.2, it shows that using 16 classes is more advantageous than using only 6. The authors demonstrate the feasibility and the quality of this unsupervised classification method. In section 5.2.4, it compares the unsupervised classification presented in section 5.2.2. It is difficult to see the link between sections 5.2.2 and 5.2.4 with section 5.2.3. Section 5.2.3 suggests that if we want to analysis microphysical properties of the snowflakes, one may want to have an expert doing it manually. Then, a list of different categories is given. This gives the impression that the method developed is not unsupervised while the goal of that section is probably simply to give an explanation of the limitation associated with the new unsupervised method developed. One suggestion would be to include section 5.2.3 into a discussion provided in the following section.

There is an important distinction to be made here between what the expert contributes to the classification process in the different approaches:

- In the supervised approach, such as the P17 scheme discussed in Sect. 5.2.4, the role of the expert is to interpret the training data before it is fed to the machine learning algorithm.

- In our unsupervised approach, the role of the expert is to interpret the nature of the classes after they are created by the machine learning algorithm unlabeled training dataset. In Sect. 5.2.3, we present this interpretation.

In the latter case, the machine learning process is entirely unsupervised and the expert only needs to examine samples from a few (in our case 16) classes. Meanwhile, in the former case the expert needs to manually interpret each item in a training dataset of thousands (in our case, hundreds of thousands) of images. So while the results of the unsupervised classification still need to be interpreted by an expert, this is orders of magnitude less work than in the supervised case. For this reason, we think we can still reasonably call our method unsupervised and we argue that Sect. 5.2.3 should be retained. Meanwhile, 5.2.4 is more of a comparison to earlier work on the same topic than another attempt to interpret the classes using different categories.

We have added text in Sect. 5.2.3 to better explain the rationale for this classification, and in Sect. 5.2.4 to explain that the purpose of that Section is to compare our results to a previously existing classification scheme rather than provide yet another interpretation for our results.

1. Line 33-35: It is mentioned that "snowflake imagining instruments have been actively developed in the recent years". I am just curious to know if other instruments similar than the MASC exists.

Yes, there exist some, those we are aware of are the Precipitation Imaging Processor (PIP, also known as SVI or PVI) developed at NASA and the Dual Ice Crystal Imager (D-ICI) from the Luleå University of Technology. We have added mentions and references for these. They have not been commercialized to the extent that the MASC has been, though.

2. Verb tense: The authors should be consistent with the verb tense used in the manuscript. For example, line 122-124 should be past tense. Please verify throughout the manuscript to make sure that it is consistent.

Throughout the paper, we have tried to follow the following convention: What we *did* during our experiments is told in past tense, while the description of what the various algorithms *do* and what the datasets contain is told in the present tense (because this is a general description of their content and functionality and not merely what happened once).

Upon proofreading the article, we found some places where, as the reviewer points out, these conventions could have been more consistently followed. We have proofread the entire article and edited to improve this consistency, with particular attention being paid to comments 2, 3, 5 and 6 from this reviewer.

3. Paragraph starting line 270: verb tense please double check.

Please see our reply to comment 2 by this reviewer.

4. Line 279-281: "However, we found that the latent. . . classification" should be clarified.

We wish the reviewer had been more specific about what is unclear about this paragraph. We have elaborated a bit to make it clearer what the point of this discussion is: That we want to exclude the variation in the latent variables that we do not want to use for classification.

5. Line 283-297: please double check verb tense.
6. Paragraph starting line 323: please double check verb tense.

Please see our reply to comment 2 by this reviewer.

7. Figures 6, 7 and 9: Does the color code represent the same variable as the number in each square? I think that it is useful to have both the number on each square and the colorbar should be clarified in the figure caption.

Yes, this is referred to as a heatmap, see e.g. here for the documentation for the package we used: https://seaborn.pydata.org/generated/seaborn.heatmap.html — the

standard recommended way there seems to be to plot heatmaps with colorbars.

We have now clarified in the figure captions that the figures are heatmaps.

8. Section 5.2.3 should probably be included in a following section comparing the unsupervised with the supervised methods.

Please see our response to main comment 2 by this reviewer.

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