Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2019-307-RC2, 2019

Atmospheric Measurement Techniques Discussions

Open Access

AMTD

Interactive comment

Interactive comment on "Unsupervised classification of vertical profiles of dual polarization radar variables" *by* Jussi Tiira and Dmitri N. Moisseev

Anonymous Referee #2

Received and published: 19 September 2019

Review of "Unsupervised classification of vertical profiles of dual polarization radar variables" by J. Tiira and D. N. Moisseev

Summary:

This manuscript details a method to classify vertical profiles of polarimetric radar observations in Finland over a three-year period. The classification method involves first processing the profiles by limiting the data to that above the melting layer, if one exists. The processed radar profiles are then transformed into principle components and subsequently clustered; the surface temperature is additionally included in the clustering for profiles without a melting layer. Based on the clustering results, the authors find

Printer-friendly version

Discussion paper

several distinct ice particle growth processes, including predominately pristine crystal growth, dendritic growth and subsequent aggregation, and Hallett-Mossop secondary ice production. Statistics of the clusters over a number of events are then presented.

Major comments:

The first major comment I have relates to producing separate classification methods for profiles with rain at the surface and profiles with snow at the surface. If the goal of this study is to identify ice microphysical processes from radar observations, it is unclear why similar processes occurring above the melting layer (for stratiform precipitation) should be identified separately from those some processes occurring in precipitation that happens to be snow at the surface. The authors have not demonstrated that ice growth in situations with rain at the surface is any different than ice growth with snow at the surface, other than the potential for increased aggregation just above the melting layer.

The second major comment I have is that the echo-top or cloud-top temperature of the profiles is more important to the ice growth processes (and is relevant in systems with either rain or snow a the surface) than the surface temperature. In fact, the presence of an inversion (found by the authors to be a common feature in their observed cases) could bias the clustering since the growth processes at upper levels of the atmosphere above the inversion have little relation to what is going on at the low levels. Having clusters essentially trained with a climatological lapse rate could then mistakenly assign profiles into the wrong growth regime if there is a strong deviation from the climatological temperature profiles during certain types of events. Some discussion of this point is warranted.

Minor comments:

1. Line 70: Add a description of the spatial and temporal resolution of the GDAS data.
2. Line 75: Clarify which radar variables have their medians calculated in linear space

and why this is being done; add reference if necessary.

3. Line 79: Does the method of KDP estimation impact the results? Add some discussion here of why this method was chosen for this study.

Line 100: How robust is the melting layer detection algorithm used by the authors if it requires the 4200-m threshold to limit detected peaks above this altitude. Some further discussion is needed here.

Line 104: Unsure what the sentence means, please clarify.

Lines 113-120: How much information does the surface temperature contain about the ice growth processes aloft? The authors should demonstrate that this surface temperature is a necessary component of the classification algorithm that improves its performance. A comparison between the clustering with the surface temperature and without the surface temperature, or similar test, would be informative.

Lines 133-135: Discuss how the PCA is performed for profiles with different numbers of bins. For example, when truncated data above the melting layer, the melting layer top will have different heights for different cases, resulting in profiles with non-uniform bins.

Lines 138-140: How were these standardization ranges chosen? Some of the upper bounds on these ranges such as for KDP and ZDR seem like they could be exceeded for C-band radar observations in certain conditions. Please discuss this further.

Line 148: Show a plot of the first principle components to provide a physical intuition of what these components represent. Also, the need for 30 principle components implies that adequately reducing the dimensionality of the radar observations is difficult. Explain how PCA is better than simply sampling the radar variables at various heights.

Lines 187-188: The description of the cluster convergence test here is unclear. Please clarify.

Lines 198-199: Are different clusters with similar profile shapes but with different magnitudes unique fingerprints of microphysical processes?

Lines 210-211: Do the authors have a specific application in mind when choosing the number of clusters to use in their study? Please discuss.

Line 216: “The order of components...” rather than “The component”?

Line 221: It may be more accurate to call this relation between peak ZDR and KDP and offset rather than an anticorrelation.

Figure 2: For cluster R3, the ZDR seems quite high so close to the melting layer. Please add some further discussion about this signature.

Line 234: Refer to figures in order; here, figures 7 and 8 are referred to before figures 5 and 6.

Line 235: Add some discussion here about whether polarimetric signatures of convection such as KDP and ZDR columns may be present in the radar observations, and therefore reflected in the classes.

Figure 3: Some of the classes are quite similar to each other (e.g., S9 and S10) to the point that it would be difficult to argue that they represent any unique fingerprints and instead reflect natural variability of the same microphysical process.

Lines 242-243: KDP values of 0.02 degrees/km and 0.04 degrees/km are both relatively low; please discuss further how this variable meaningfully separate the R0-3 and R4-5 classes. Also, what does the subscript “c” indicate with respect to the radar variables (found here and later instances)?

Figure 5: Explain why the ZDR centroid curve doesn’t correspond to the profiles (i.e., shaded region) above 6 km.

Line 245: How common is it for precipitation systems in this region to have moist adiabatic lapse rates?

Lines 251-252: How do the authors separate out the contributions to KDP of planar crystals generated aloft and sedimenting from the KDP produced by secondary ice from the Hallett-Mossop process?

Lines 272-274: The maximum KDP values for the S14 class are much smaller than those for the S15 class, and the heights of the maximum ZDR values between these classes are also different. Discuss how these different profiles can both indicate a similar fingerprint of dendritic growth.

Line 283: Clarify here whether both processes are occurring within the same profile but at different heights or there are dendrites that have fallen into the Hallett-Mossop region where that processs is also ongoing.

Line 300: Add the color scale indicating the classes to figures 7 and 8.

Figure 7: Explanation for negative ZDR just above melting layer?

Figure 8: The ZDR profiles for this case appear fairly noisy. It might be helpful to show an RHI for this case, especially from the early portion of the event, to understand how much of the variability in the ZDR profiles is due to noise in the actual radar data.

Line 371: If these archetypes represent the desired output of the classification algorithm, doesn't this imply that the number of clusters (10 and 16) used in the classification algorithm is too high? Why not use 7 clusters in the algorithm?

Line 389: It would be beneficial to add some discussion here of the potential to identify the process of heavy riming, where ZDR values may become negative, as well as some indication of how common this process is in Southern Finland.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2019-307, 2019.