

Atmos. Meas. Tech. Discuss., referee comment RC2
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Comment on amt-2021-137

Anonymous Referee #2

Referee comment on "Using artificial neural networks to predict riming from Doppler cloud radar observations" by Teresa Vogl et al., Atmos. Meas. Tech. Discuss.,
<https://doi.org/10.5194/amt-2021-137-RC2>, 2021

General comment:

The manuscript developed artificial neural networks to estimate rime degrees within ice precipitating clouds using limited data. It is a novel approach to establish ANNs using vertically-pointing radar data. The manuscript well written including detailed enough descriptions of the ANN technique, although I have a few questions about the technique and method. The figures are appropriate. I also have a few questions/concerns that should be clarified before considering publication.

Specific comments:

- It was not clear to me why the authors employed the ANN technique rather than a standard technique that explicitly estimates empirical equations e.g. $FR(Z_e, MDV, SEW, skewness)$, $FR(Z_e, SEW, skewness)$ as Kneifel and Moisseev (2020) derived $FR(MDV)$. I think that deriving such empirical equations is not so hard. Please clarify the advantage of using ANN techniques compared to others.
- A major concern is that this study lacks quantitative evaluations of the established ANNs. The evaluations of the results from the applied ANNs presented in this manuscript are all qualitative, and only a few of short periods near the surface are picked up to compare the results with the in-situ measurements. I understand that the qualitative evaluation of the selected short periods is valuable, but quantitative evaluations, including the entire periods of the application cases, should also be more valuable.
- It was not clear why the authors used SEW instead of Doppler spectrum width. What microphysical/dynamical processes does SEW represent? How do those processes

impact the ANNs? What is the advantage over the Doppler spectrum width? Doppler spectrum width is a standard moment parameter, which is available for even radars that do not collect Doppler spectra, whereas SEW requires Doppler spectrum data, which are expensive for many radars.

- As the authors pointed near the end of the manuscript, SEW can be strongly influenced by turbulence broadening. Why did the authors use SEW in both ANN1 and ANN2? My specific questions are:
 - For the significant turbulence cases, if SEW was not used in an ANN, could the result be more reasonable?
 - Can you quantify the uncertainty attributed to the turbulence broadening in the ANN-based rime degree estimate?
 - Can you train the ANNs to minimize the turbulence broadening effect?
 - SEW depends on sensitivity. Do the ANNs work with different systems that have different sensitivity?
- The manuscript needs descriptions about how to deal with attenuation effects.

- Were the radar data corrected for attenuations? The attenuations affect not only reflectivity but also MDV and SEW. Especially, SEW might strongly be affected by the attenuation.
- Do the attenuations for hydrometeors and gases affect the prediction and the accuracy of the established ANNs?
- Especially the Fig.4's case includes many regions of rain, so the attenuation must be significant. Does the attenuation influence the riming prediction above the melting layer?
- One of the findings of this study is that the ANNs can be applied at a different cloud radar frequency. Do the attenuation effects influence this?

- Section 2.2: When I first read this paragraph, it was not clear whether those processes described in this section were applied to all datasets from all sites or only the BAECC datasets. I suppose that they were applied to the BAECC datasets, which were used as training datasets, correct? Please clarify here.
- 9 line 24: Please describe why the performance of the ANN #0 is much worse than for the others.
- 10 lines 1-2: Please explain more why "riming index" is used instead of FR. What is the relationship between riming index and FR? Please explain more why the output from the training process is different from FR for readers that do not have expertise in ANN.
- Section 3.2: Most of this case seems to have a melting layer, meaning rain near the surface. Which height/time was characterized as "aggregation" or "riming"?
- Figure 6: Many data points with higher riming index > 0.7 are deviated from the pink line. Are they accurate predictions? I think that adding the same plots but with color scales with FR will be useful.
- 21 line 19: In cases where MDV is not available due to orographic effects, SEW could also be impacted by a turbulence.

Technical comments:

- 4, line 10: SEW is first used here.
- Table 1: Please give the total time of the datasets used. This would also be useful.
- 9 line2: I am not sure if five folds are enough for the validation process. Could you evaluate/explain that the number is appropriate?
- P10 line 18: What is the unit of 0.7 and 0.9?
- Figure 2: Please add temperature contours similar to Fig. 5.
- Figure 3: Please add time series of FR estimated from the in-situ measurements and compare it with the riming index from the ANNs.
- Were DWRs corrected for attenuations?
- 13 line 15: When is the riming period?
- 4d: Please use appropriate color scale.
- Figure 5: Is it possible to have riming with $T < -40\text{C}$ (0.4 riming index)?
- Legends on Figs. 5a-5d present all "W band."
- Figure 6: I think that the four panels in this figure used the same dataset, and the distribution of the data points should be same. Why is the distribution in the plots in the left column and the right column different?
- Figure 8: Could you add time series of FR estimated from the in-situ measurements or similar parameter from the image analysis?