Atmospheric Measurement Techniques Discussions

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Comment on amt-2022-160

Anonymous Referee #2

Referee comment on "Image muting of mixed precipitation to improve identification of regions of heavy snow in radar data" by Laura M. Tomkins et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-160-RC2, 2022

Overall Recommendation:

The authors present a new reflectivity visualization technique that aims to decrease cognitive load on radar analysts by muting reflectivity in areas classified as mixed precipitation. I think there is a possible application of this technique for those who would potentially struggle with appropriately diagnosing higher reflectivity associated with melting. However, operational meteorologists are generally trained in awareness of the brightband. Moreover, the spatiotemporal evolution of winter storms (relative to severe convective hazards) allows for more time to analyze multiple products, etc. Thus, I struggle to see a significant need in the operational community for such a tool, at least given some of the concerns/shortcomings I mention below (muting of important features, simple thresholds, etc.). I think this paper could be a worthy contribution to the literature if these concerns are appropriately addressed via either a) making a stronger argument for how this would be beneficial for operational meteorologists and/or b) framing it more for non-meteorologists. Additionally, shortcomings in the algorithm logic/performance need to be addressed.

General/Major Comments:

- Winter weather scenarios, while challenging in different ways from severe convective scenarios, tend to evolve on longer timescales than severe convective scenarios. Is the time pressure in winter mixed precipitation events that high to necessitate this image muting technique for operational forecasters? Is there evidence to support this claim that even experienced meteorologists are mistaking bright banding for heavier precipitation? Not saying it isn’t occurring, but is it occurring enough to necessitate a new product? I would argue this is more of a training issue for forecasters vs the need for a separate product. That said, I could see more value in such a product being presented as a visualization tool for non-meteorologists in weather-sensitive fields (e.g., emergency management) or for the broader public, perhaps in weathercasts or in apps. I wonder if it might be beneficial to emphasize this technique as a presentation tool for non-meteorologists.

- **Section 2.2**: I have concerns about the thresholding process. First, by filtering out light echoes (less than 20 dBZ), you do miss areas of mixed precipitation. I've witnessed scenarios with light crystals generated at low levels (e.g., top of the boundary layer) that then melt near the surface. In those instances, correlation coefficient (CC) can remain reliable, while still suggesting the presence of mixing. In these cases, a user of this product could think that these light echoes might be pure rain or snow, when it's mixed precip in reality. Moreover, what's the advantage of using flat CC/Z thresholds to identify mixed precip when other algorithms (like the 88D Hydrometeor Classification Algorithm) take into account more data in a more nuanced fashion? Would these not perform better at identifying mixed precipitation? Could you use such an algorithm as input into a more advanced muting technique?
- **L78-81:** I'm glad the algorithm isn't muting reflectivity at farther ranges, but I think the reasoning here is incorrect. Frequently, the reason lower CC is dominating at these ranges (at least for the 88D network) is due to the radar sampling echoes at higher altitudes / colder temperatures, within the crystal generation region. The mixture of crystal habits is what's often driving CC downward. It isn't an unreliability of the signal. At a minimum, I think this is somewhat "getting it right for the wrong reasons." Most of the time, this crystal growth region should be characterized by relatively low Z, such that I don't think this would be a huge issue for the current design, but I think this needs to be corrected / clarified.
- **L85**: A couple comments here, one minor, one major. The minor one is that I think these linear features need to be annotated/circled on the figure so it's clear which linear features you're talking about. If I am correct about the linear features to which you are referring, then here's my major comment: I'm not sure how helpful it is to mute them. The reason why is that this specific line of low CC / high Z (on individual radars, it's often a line that connects a semi-circle of low CC, which is the primary melting layer) represents the edge of the melting layer aloft, where we tend to see the melting layer descend some to the surface because temperatures are only barely above 0 C aloft, extending the melting process and allowing mixed precip to reach closer to the ground. Within this linear band, we very frequently see a zone of sleet pellets at the surface as partially melted snow falls back into a sub-freezing layer and quickly re-freezes into sleet. In fact, your Figure 4 shows this very clearly with both the radar structure and the reanalysis temp x-section. That muted line across southern Long Island is where extremely heavy sleet (i.e., inches of accumulating sleet) was occurring (Fig 6 and related discussion in Picca et al 2014). Do we want to mute such a microphysically important feature that has large implications for surface impacts? If you're just looking for pure snow, I guess it's OK, but I have large concerns about drawing attention away from this feature, at least for an operational meteorologist. Once again, for the public / non-meteorologists, I think this is fine if you wish to present a 'snow map' of sorts, but I have my doubts for forecasters. This is critical information. And if they then have to go look at CC / switch products for clarification on this muted zone, what's the point of the algorithm? I think a sizable explanation is required here to address these concerns with the current design.
- **L125-132**: In Figure 5 for this case, the melting layer is very evident, starting at about 100 km range (except for the collapsed portion to the north). Often at lower elevation angles and more extended ranges, the melting layer presents as a broad area of 'speckly' CC, presumably due to the decreased resolution / increased volume size. With that in mind, pockets of CC > 0.97 often occur in this zone, where perhaps the volume is encountering mainly one precipitation type (e.g., snow just beginning to melt or rain almost entirely finished with the melting process). These zones often are still

characterized by higher reflectivity and we see that in Fig 5. Due to the 0.97 threshold, though, much of this melting ring is not muted, showing a shortcoming in this technique. Given this is clearly a zone of higher reflectivity associated with mixed precipitation, the lack of more widespread muting is concerning.

Minor Comments:

- **L12**: Why specify coastal regions? There are plenty of mixed precipitation winter storms across the interior US.
- **L30-42**: Related to my comments above, I wonder if this is truly problematic for trained analysts. Most radar software offers multi-panel views that can show Z and CC (along with other variables) side by side, reducing the need for switching, etc. Additionally, winter weather scenarios evolve on slower timescales, attenuating the cognitive load issue. Would it be better to suggest/emphasize this as a visual tool for presentation to non-meteorologists?
- **L53-55**: Is it technically more accurate to say "...4 km above radar level" ? Radars located at higher elevations may be scanning above 4 km AGL in some areas within 200 km range, due to land sloping downward from the radar. For instance, I think High Plains radars like FTG are scanning over 4 km AGL within 200 km range to the east.
- **L105**: Would clarify that "height of the radar beam (black X in Fig 2b)" refers to height of the 88D data used to construct the regional mapping. You do so in the figure caption but it was confusing as I read the main text because "radar" is ambiguous. At first I thought it referred to the on-board radar, which doesn't make sense of course since that's a nadir-pointing radar.
- **L118-124**: I suspect some, if not all, of this particular shape in the melting layer structure is because the very close range to radar allows us to resolve this structure much better (and at much lower altitude) than is usual with the 88D network. The end result of this arc-like structure is that we see re-freezing into sleet pellets within that cold air closer to the surface (as I mention above in my major comment). We almost always observe sleet pellets underneath these linear features on the edge of the 0 C isotherm aloft, which would suggest this thermal structure is pretty common and the defined arc structure is more a case of radar resolution, rather than an anomalous thermal environment. See Fig 11d in Griffin et al 2014 https://journals.ametsoc.org/view/journals/wefo/29/6/waf-d-14-00056_1.xml?rskey=9QTt6F&result=1

Figures / Tables

- **Table 1**: The caption is oddly written. Suggest changing to something like "The correlation coefficient values associated with physical mechanisms that increase snow radar reflectivities when other conditions are held constant." Additionally, I think some further clarification could be necessary. In the first two columns, you are not specifying the nature of the ice particles. If it's a diverse array of crystal types, CC can be lower than 1. While not dramatically lower (let's say 0.95-1), I would say "~1" does not accurately describe such a scenario. Probably should add a condition in which we assume uniform particle habits, if you wish to maintain "~1"

- **Figure 3**: Since the text and the data from Fig 2 only discuss the precipitation types / radar from around 16 UTC, why do you include all of the other times from ASOS data? I think if the text / analysis comprehensively discussed the p-type changes over time at the various sites, it would be more relevant, but as it stands right now, I'm not sure why you present the other times. You do mention the transitions at KBGM in lines 111-112, but there is no synthesis with the algorithm / radar data. This would be a much better analysis if, for example, you included mosaicked algorithm output around these transition times and compared those data with the ASOS data. Without them, the additional data in Fig 3 are distracting and unnecessary.