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Atmospheric Measurement Techniques
Discussions

Interactive comment on "Fuzzy logic filtering of radar reflectivity to remove non-meteorological echoes using dual polarization radar moments" *by* D. R. L. Dufton and C. G. Collier

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We would like to thank the reviewer for their constructive review and comments; we've taken them on board and amended the paper to improve its clarity. Below are the reviewers points in italics, followed by our response and then the amendments we have made to the paper in blue.

1. "Most, if not all, of the construction work of the multi-vertex membership functions has been done by using human expert identification, where and when possible this expert opinion has been supported by additional information e.g. raingauges data.

This "opinion" is a strong, but contemporary, a weak point of the process. Indeed there is no other way to consolidate classification. Authors could for example try to compare their result with the outcomes of other researchers, in order to highlight an hopefully minor number of mis-classification echoes."

Most quality control algorithms have a very specific set of spurious echoes which are removed, for example both Gourley et al. (2007) and Rico-Ramirez and Cluckie (2008) just use a meteo to non-meteo lumped removal, while others focus on a single source of clutter, Lee et al. (2014) focus on chaff for example. This makes direct comparisons between these methods and ours, which aims to distinguish between sources of clutter, difficult. Specifically we want the option to allow insect retrievals to be maintained for studies of convergence in our convection studies. However the reviewer raises an interesting idea for a comprehensive review paper, whereby in addition to covering the literature the variety of different schemes available are tested using the same data.

2. "Other weak point, even if not critical, is the limited set of data used. For personal experience one filter technique could be very effective in one event, but it could be less effective in others event with a greater number of rejected "good" data or non rejected "bad" data. A more extensive test is needed."

We have presented a range of cases from our available dataset that show the algorithm successfully operating in different conditions (convective vs stratiform, summer and autumn), but accept that a wider analysis would be beneficial when we gain more data. We would particularly like to assess performance for winter data, which we do not currently have available. Section 4.3 and Figure 9 from the paper assess the effectiveness of the filter in a wider sense for the data we do have, as it is not possible to present every case we have available and show its success in these conditions. In the conclusions we have highlighted areas for improvement and these will be worked upon as more data becomes available.

3. "Further the last week point that need to be pointed out is the behavior of such tech-

nique to the attenuation. The paper present a filter technique developed for an X-band radar. As well known short wavelengths are severely affected by such phenomena. A more deep discussion to clarify why it wasn't correct is expected."

As you quite rightly mention attenuation can be a significant issue for X-band radar, and there are now many approaches to its correction which use dual polarisation variables. In this work we have not corrected for attenuation, as we believe it is important to filter out spurious echoes prior to correction, particularly when using a derivative of the ZPHI method (Testud et al., 2000) as we intend to do. Inclusion of spurious reflectivity measurements can lead to inaccurate distribution of path integrated attenuation, attributing attenuation to clutter rather than attenuating rainfall, while using unfiltered Φ_{DP} can introduce significant noise and clutter artifacts into the correction. As misclassification is sometimes present around intense attenuating cells which cause strong gradients and significant bias in reflectivity, we explored the possibility of using a simple linear correction prior to echo classification to improve this. However this showed no positive benefits in improving misclassification, which is more strongly linked to ρ changes and texture resulting from gradients of variables across the beam. To clarify we have added to section 2 of the paper to cover the absence of attenuation correction in this work and we will continue to work on improving classification in strongly attenuated regions.

Added: "Prior to the analysis presented here, reflectivity and differential reflectivity were corrected for radar miss-calibration and frequency drift using a modified version of the self consistency approach presented by Gourley et al. (2009). Correction for attenuation has not been applied, as correction using the commonly applied ZPHI method (Testud et al., 2000) requires clutter filtered data to accurately distribute attenuation along the rain path. Attenuation correction of the data will follow in future work, after the application of the clutter filter and removal of non-meteorological echoes."

4. "Page 5027 line 11 - this reference is quite outdated. please add something more new."

New reference added, thank you.

Added: "Löwe et al., 2014" to p5025 line 11

5. "Page 5029 line 1 - Zdr ranges depends on the band used. Non Rayleigh scattering effects are present at short wavelengths."

Non-Rayleigh scattering at X-band impacts the Zdr in the 3-4mm drop diameter range, and is otherwise generally comparable to S-band (Ryzhkov and Zrnic, 2005). We have added to the paper to clarify this.

Added: "As drop size diameter increases non-Rayleigh scattering can occur, this effect happens sooner at shorter radar wavelengths. This affect is most prevalent at C-band, with strong resonance above 4.5 mm while X-band experiences minor resonance at around 3 to 4 mm diameter (Ryzhkov and Zrnić, 2005)"

6. "Page 5037 section 3.2.2 - Please explain better the terms of equation 2. The text is no so clear."

Thank you, we have split the equation for clarity and amended the text as follows.

Changed section from p5037 line 20 to:

F(x) = F(x)$_K \times F(x)_J$

where

F(x)$_J = \sum_{j \in J} M(x)_j$

and

F(x)$_K = \prod_{k \in K} M(x)_k$

Individual membership scores ($M(x)$) for each parameter are calculated using the defined variable vertex membership functions. Those parameters which form the additive group (J) have their totals summed to calculate the additive total ($F(x)_J$). Those parameters in the multiplicative threshold switch set (K) conversely have their totals multiplied together to calculate their total ($F(x)_K$). These two totals are then multiplied together to calculate the final class scrore ($F(x)$). The multiplicative threshold parameters are used to suppress certain classifications based on observational constraints, such as ground clutter being suppressed where normal beam height exceeds 2 km or insects where Z_{DR} is below 0.5 dB. This is in contrast to the post classification decision suppression employed in other classification schemes (Gourley et al. 2007) . The total score($F(x)$) is then converted to a fraction of the maximum possible score obtainable for that class.

References

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