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Atmospheric Measurement Techniques Discussions

Interactive comment on "Detection of the freezing level with polarimetric weather radar" *by* Daniel Sanchez-Rivas and Miguel Angel Rico-Ramirez

Anonymous Referee #2

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Review for AMT-2020-375

"Detection of the freezing level with polarimetric weather radar"

Daniel Sanchez-Rivas and Miguel A Rico-Ramirez

This study proposes an approach to estimate the freezing level (FL) using vertical/quasi-vertical profiles (VP/QVP) achieved from polarimetric radar observations. The proposed approach was applied to some selected events, and the estimated FLs were evaluated using radiosonde observations. Based on the evaluation results, the authors concluded that the combinations of ZH, HV, and the gradient of the velocity V, and ZH, HV, and ZDR for each VP and QVP method are the best predictors for the FL estimation. I think that the study was well-designed, and the focus and experimental

details and results of the study are clearly addressed in the manuscript. However, I have a basic question about the utility of this study for radar QPE and additional comments/suggestions for some other aspects presented in this study.

Major comments:

1. Utility of FL height The authors discuss the necessity of FL information for radar-based applications (e.g., QPE) in Introduction. In my opinion, what is really useful for radar applications is to provide a range of the melting layer (ML), not just a single value of FL height itself (as this study mostly devoted to find the FL height) because mixed (liquid-solid) precipitation is usually located below the FL height, and this is a significant challenge e.g. for rainfall and attenuation estimation. I am wondering what specific applications require the estimated FL height. I think that a bottom height of the ML presented in Figures 10 and 13 is much more useful than the FL height itself because the majority of scattering and propagation theories can be applied only to the region below this height (liquid precipitation or pure rain region).

2. QVP It is not clear if either time-averaged or instantaneous QVP is used in the proposed FL detection algorithm. I think that instantaneous QVP is not appropriate for the proposed algorithm because it could be affected by local storm structures (although it is derived from higher elevation angles) particularly for the ones near the radar. If the authors used time-averaged QVPs, they need to clarify it and define the averaging time window.

It might be helpful for readers to understand the QVP method if the authors provide a brief description on the background and procedures to retrieve QVP from radar observations, rather than just referring to Ryzhkov et al. (2016).

3. FL spatial variability I think that the proposed QVP method results in the average FL over the entire radar domain while the VP method yields limited FL to the radar site (if VP was obtained from a 90 degree elevation angle). I am wondering how the spatial variability of FL over the radar domain looks like, and the authors may compare the

FL information retrieved from the NWP model with the one achieved from this study. It might be helpful to discuss this spatial variability issue in the discussion section as a limitation of this approach.

4. Error analysis Whereas the analyses presented in this study focused on finding the best predictors of the polarimetric radar observations, it is valuable to characterize the structure of errors resulted from the proposed methods. I think that it would be useful to demonstrate error distributions of each VP and QVP method (e.g., P14 and P26), rather than just reporting "the errors in the FL estimation using either VPs or QVPs ae within 250m."

Minor comments:

1. Line 10 Maybe better to remove "extremely."

2. Line 24-26 It would be interesting to compare the FL heights computed from between this study and the NWP model.

3. Line 87 Please define "UKMO."

4. Line 106 Please replace "twice daily" with "twice a day."

5. Table 1 I think that the "Location" in Table 1 represents coordinates on a certain projected coordinate system. Geographic coordinates are more common and please provide latitude and longitude of the radar site.

6. Figure 2 Please use consistent height (y-axis) and color scales for the same radar observables to enable easy comparisons between left and right panels for (a)–(h). Please also define "HTI" in the figure caption.

7. Line 144 Please clarify if QVPs shown in Figure 3 were time-averaged before they were normalized.

8. Line 181-182 How are "type of precipitation" and "phase of the hydrometeors" different?

9. Line 278 It turned out that "magnitude (k) of Ppeak" was a threshold (e.g., parameter) for peak magnitude (Line 287). Please clarify it here.

10. Line 291-294 Something is missing. Please rewrite.

11. Line 300 Why do the authors compare VPs and QVPs? Is this comparison performed because the authors used instantaneous QVPs for FL estimation? I think that they (VP and QVP) are not necessarily consistent, and QVP should be used with time-averaging to avoid local storm effects and capture the consistent vertical structure with VP.

12. Section 5.2 This section does not describe the result of this study and should be moved to the "Methodology" section.

13. Line 352 Please replace "better" with "best."

14. Line 358 Why P16? Both ZH and [grad V] are the elements of P26. [grad V] was used for P16–P31, not just for P16.

15. Line 359 Figures 10a and 10b instead of "Figures 13a and 13b?"

16. Line 361-362 The estimation procedure of the ML bottom was not described.

17. Line 383 Please replace "better" with "best."

18. Line 386 Why P10? P10 does not have to be mentioned here because the two factors shown in Figure 13 are also included in P14.

19. Line 404-407 I think that the ZDR calibration bias is not an issue in this study because relative ZDR values (e.g., normalized) are used to construct vertical profiles. ZH also contains the calibration issue.

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