Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC3
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Comment on amt-2022-169

Anonymous Referee #3

Referee comment on "Improved spectral processing for a multi-mode pulse compression Ka–Ku-band cloud radar system" by Han Ding et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-169-RC3, 2022

This manuscript presents methods to remove clutter and range sidelobe artifacts in vertically pointing radar Doppler velocity power spectra. The manuscript also describes a method to combine spectra from four different modes to produce a merged moment dataset.

It appears that the authors have done some good research exploring Doppler velocity power spectra, yet, the manuscript does not provide enough quantitative analysis for an AMT reader to adapt the proposed methodologies to different radar systems.

Also, the manuscript does not provide enough examples of “clutter” in different weather conditions to convince this reviewer that the radar is observing non-meteorological clutter. From the imagery presented in the manuscript, it appears to this reviewer that the “clutter” is actually clouds being detected in the same radar resolution volume as precipitation. One possibility is instead of identifying and removing “clutter” from the power spectra, the manuscript should explore using multiple-peak processing methods to identify multiple hydrometeor populations occurring within the same range resolution volume. For example, in Fig. 1a, it appears to this reviewer that the radar is detecting both raindrops (with Doppler velocities exceeding 8 m/s) and cloud particles (with Doppler velocities near zero).

I encourage the authors to continue their work analyzing Doppler velocity spectra and make improvements to this manuscript.

Major Concerns

1. Line 117. The text states, “..the implementation of pulse compression techniques in modes 2 and 4 usually results in significant range sidelobe around the melting layer, which does not significantly affect Ze and V estimates, but can severely degrade the estimation of spectrum width.” This sentence is not logical. If there is “significant” range sidelobes,

then power that should be assigned to the central range gate is being “significantly” distributed into different range gates, and Ze and V will be incorrect in the central range gate and in the range sidelobe gates. Will the error in Z and V be “significant”? This manuscript needs to describe how much power is leaking into the range sidelobes and how that is affecting the Ze and V estimates. Including that quantitative analysis through simulations or detailed analysis would be valuable to AMT readers.

2. Figure 1 and Line 135. “The cause of such clutter signals is unclear yet we hesitate to classify them to insects (Williams et al. 2018), since the spectral powers at different modes deviate from each other significantly.” This reviewer agrees, the spectral peaks near zero velocities are probably not due to scattering from insects. From examining Fig. 12, it appears that the spectral power near zero velocity is scattering from clouds. Thus, Fig. 1a probably shows return power from precipitation and cloud particles. In Fig. 12, between time 20:00 through 21:00 LST and near 2 km, there is a cloud feature in the reflectivity and velocity time-height cross-sections that suggest this 'cluttter' peak near zero velocity in Fig. 1a is scattering from cloud particles being detected in the more sensitive modes 4 and 2. The manuscript should provide more imagery of this “clutter” signal to convince the AMT reader that the radar is observing non-meteorological clutter. For example, a time-spectra plot showing spectra at one range gate over multiple profiles could indicate whether this signal is coherent over many profiles, indicative of a cloud.

3. Line 144. “The selection of |Delta S| = 3 dB is a compromise …”. The manuscript has omitted important processing steps needed to compare different operating modes collected from the same radar system. Specifically, the manuscript needs to describe how the spectra from the different modes are cross-calibrated. Each mode has their own noise level, sensitivity, and velocity resolution such that the Doppler velocity power spectral density magnitudes will not be the same for the different modes. The modes must be cross-calibrated and scaled in order to produce the spectra shown in Fig. 1 in units of dBZ (this includes a calibration offset plus range squared correction). Regarding the 3 dB threshold, the manuscript needs more analysis showing the range of power differences between the modes in order to justify a particular threshold so that AMT readers to apply the proposed technique to other radars.

4. Section 3.2. This section is very confusing for the reader and needs to be re-written.
a. The manuscript needs text describing the physical process that is causing the range sidelobes. That is, the de-coding of the phase modulated signal has errors and is causing power to appear in the wrong range gates.

b. Line 173. The description “sidelobe caused by the pulse compression drags a long tail in the relatively large velocity bins…” is not correct or is poorly worded. The range sidelobe does not move power (or drag power) into different velocity bins to cause a long tail. The power appears in different range gates at the same Doppler velocity. Please clarify text.

c. Lines 177- 187. The description of the PDF powers is not described well. I do not understand what analysis techniques are being performed in this paragraph.

d. Figure 4 is confusing.

e. While the manuscript describes the excess power above the melting layer, the manuscript does not address the excess power in the range gates below the melting layer. The manuscript should include a range sidelobe correction for range gates below the melting layer.

5. The text on Line 223 states, “This effect leads to the underestimation of V, which is critical in the merging process, and Ze.” And line 235 states, “In Fig. 8a1, significant biases of Delta Z and Delta V can be identified, and Delta V increases with Delta Z.” There are several issues:
a. Fig. 8a1 does not show Delta V increasing with Delta Z.

b. Fig. 8a1 does not show that coherent integration in mode 1 is causing a bias in Z and V relative to mode 3. In fact, the reflectivity difference shown in Fig. 8a1 is of the wrong sense with mode 3 having a smaller reflectivity than mode 1 (Delta Z = mode3 - mode1) Also, there is not a velocity difference between mode1 and mode3 in Fig. 8a1.

c. The manuscript needs to describe the expected differences in Z and V due to coherent integrations and then verify these expectations with the observations.

6. Figure 12. There is still “clutter” in the moments shown in the left-hand panels. The clutter is present when there is no surface precipitation between 2 and 3 km height and between 20:45 and 21:00 LST. The clutter needs to be removed from this figure or text must be included describing why the clutter is still in this figure. See comment #2, the manuscript needs to verify that the “clutter” in Fig. 12 is due to either non-meteorological scattering or due to cloud particle scattering.

Suggestions
7. Line 43. Define 'non-meteorological clutter'. Is the manuscript referring to reflection from stationary targets (e.g., buildings or poles) or moving targets (e.g., insects, birds, or power lines moving in the wind)?

8. Table 1. Include the radar operating mode names to table (i.e., boundary layer mode, cirrus mode, etc)

9. Table 1. Include the transmitted pulse length (time and distance) and number of code bits in each mode.

10. Figures 12 and 13. Both figures show a gap in cloud structure near 2 km between 20:00 and 20:30 LST. It looks like the mode3 (right panel) shows low level precipitation that does not extend above 1 km and another mode is detecting precipitation above its blind zone near 2 km. The text should mention the vertical gaps in precipitation features and they are due to blind zone issues and different sensitivities of the modes.