

## **Full review of Williams et al., AMT 2018**

### **General comments**

The study titled “Clutter Mitigation, Multiple Peaks, and High-Order Spectral Moments in 35-GHz Vertically Pointing Radar Velocity Spectra” by Christopher R. Williams et al. describes three techniques used to improve the quality of high-order radar moments determined from 35GHz vertically pointing cloud radar Doppler spectra. This technical paper focuses on the detailed description and benefit of the processing methods. The first method can be regarded as pre-processing step as it shows how to remove ground clutter returns in the radar Doppler spectra caused by antenna side lobes and reflections of a nearby scanning cloud radar. In the second technique, the identification of multiple spectral peaks and the determination of their radar moments are presented. The third method focuses on improving the quality of higher-order moments (spectrum width, skewness, and kurtosis). It was demonstrated that 2-s temporal scale turbulent broadening can be removed by shifting all 2-s spectra to a common 15-s mean Doppler velocity before averaging.

### **Open question:**

I would suggest the manuscript to be published after minor revision. The authors should address the following points:

### **Major comments**

Abstract: You mention cloud and drizzle particles causing non-zero skewness. Since you do not explicitly mention what kind of clouds you are analyzing, the reader might think you focus on liquid-only clouds. This is misleading as you actually look at mixed-phase clouds, too. Please mention in the abstract to which clouds your technique can be applied to. Also specify briefly, if the described three techniques will be/are implemented in routine data processing of the ARM program or if new data products are planned or older ones enhanced by your methods. In technical papers, the challenge is always to provide detailed description of the methodologies while at the same time maintaining readability. This is often reached by splitting long sentences into two. Please check where this can be done.

Some of the thresholds described in the flow diagram (Fig10) seem a bit random:  
p.8 line 22: Shouldn't the requirement of “number of spectral points above noise threshold” be a function to the spectral resolution thus be different for let's say the 256 vs 512 FFT points?

p.8 line 36: Why did you opt for “at least three neighboring pixels” in the 3x3 time-height continuity filter? Did you try other thresholds and if so, did results differ much?

p.9 line 36: How did you come up with a 6dB “valley” between the most significant peak and the subpeak? Did you try other thresholds and if so, did results differ much? Is this threshold based on radar forward simulations or empirically-based? Shupe et al., 2004 for example described that their peak-picking criteria were empirically based. They state that “For two continuous modes above the noise to be considered distinct modes, the saddle point between the peaks must be lower than 65% of the lowest of the two peaks from the noise level.” – Did you try this instead of a fixed 6dB threshold?

In general, it would be desirable if you motivate the choice of your thresholds, compare your threshold values against literature values and discuss differences/advantages of your thresholds.

p.10 line 29: Again, please motivate why you chose 15-s integration intervals.

Please specify the thresholds for moment estimation: mean or max. noise floor?

### **Minor comments**

p.1 Line 13: The phrasing is a little bit misleading: It sounds as if only the first method is applied to KAZR data.

p.1 Line 18: Unclear if “unique peak” refers to noise-floor separated peak. Please rephrase to clarify.

p.1 Line 19 etc.: Explain why you use the term “breadth” instead of spectrum “width”

p.1 Line 20f: Last sentence of the paragraph explains the third method (in the previous sentence) again. – For the abstract, I suggest leaving out this last sentence or merging the two sentences to save space.

p.1 Line 27: I suggest rephrasing to “...indicator of possible multiple hydrometeor populations”

p.2 Line 24ff: I suggest replacing “weather signal” with “hydrometeor signal”

p.4 Line 25: switch “only” and “for”

p.7 Line 22-24: This sentence is unclear. – Please rephrase.

p.8 Line 9-10: This sentence is unclear. – Please rephrase.

p.8 line 14: How can the residual peak magnitude velocity be at “either” 3-point interpolation edge velocity?: The middle velocity of the 3-point interpolation is not an edge velocity. – Please rephrase for clarity.

p.9 line 12: Did you have a look at the radar spectral LDR signature to discriminate spherical (likely liquid) particles from non-spherical ice particles?