Reply on RC1

Matthew A. Miller et al.

Author comment on "Detecting wave features in Doppler radial velocity radar observations" by Matthew A. Miller et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-256-AC1, 2021

We would like to start by thanking the reviewer for volunteering their time and expertise in reviewing our manuscript. We appreciate the constructive feedback. Our responses are made inline to selected reviewer comments below. The original reviewer text is in bold. Our replies are in italics.

One thing I kept thinking of while reading the paper is the role of collective variability of the hydrometeor fall speed, vertical air motion and horizontal air motion in determining the radial velocity field. Some of the "wave-like" features determined here could be purely referring to changes in hydrometeor fall speed, and large boundary layer eddies that tend to orient themselves along the prevailing wind. This is further complicated by small congestus clouds embedded in the large precipitation field observed by the WSR-88D. It will be good to discuss this issue, and maybe do some back of the envelope calculation of the error such and phenomenon might cause. Thanks.

For the cases we illustrate, the radar elevation angles are sufficiently low that we expect little or no impact on the observed radial velocities. The contribution of the hydrometeor fall speed to the radial velocity is equal to the sine of the radar beam elevation angle. For a 0.5 degree beam, only 0.9% of the fall speed contributes to the radial velocity. Snow with a 1 m/s fall speed contributes only 0.009 m/s and for larger rain or grauple particles with fallspeeds of 5 m/s that is still only a contribution of 0.045 m/s. The radial velocity data for a WSR-88D radar only has a precision of 5 m/s. Thus, we don't expect variations in hydrometeor fall speed to be a factor in the wave detection method.

The WSR-88D radar has insufficient sensitivity to observe non-precipitating clouds such as cumulus congestus.

We have observed boundary layer eddies in research radar data sets from winter storms. These research radar observations typically have a vertical resolution < 50 m and the eddies typically occur in the lowest 1 km of the atmosphere. The WSR-88D radar rarely sees boundary layer eddies in winter storms since with increasing range the beam rapidly becomes too wide and too high to resolve them (see Figure below).

1 deg beam width, 0.5 elevation angle scan
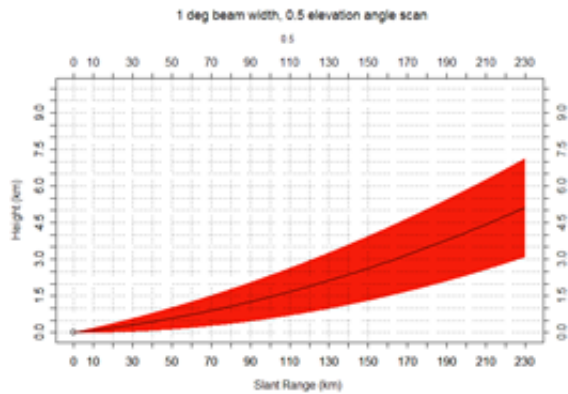
The authors have only used data from the negative velocity perturbations. It will be good if you can mention if you get similar results if you used positive perturbations. I assume that the positive perturbations will have less contamination from the falling rain, and hence might be more robust.

In practice, we have found that using the negative versus the positive side of the perturbation makes no difference for wave identification. For real-world data where the waves are not perfectly symmetric, the positive and negative parts of the wave do not perfectly mirror each other. We have not noted a difference in noise or anything similar between the positive and negative velocity perturbations. We encourage the reviewer to reexamine the radial velocity difference fields in Figures 2, 5, 6, and 7 along with corresponding binary fields while keeping in mind that the human eye is more sensitive to gradations in red than in blue. Our interpretation of these data both by visual and mathematical comparisons is that the positive and negative areas are not meaningfully different from a wave identification perspective.

The simulator is great. However, I could not understand the fall speed or the drop size distributions used in the Figures 3 and 4. It will be good to mention those. Thanks.

Fall speed and DSD are not considered at all. For the purposes of the idealized simulator we made, the velocity perturbations are prescribed directly.

Line 27: it will be good to define mesoscale here. I assume you mean meso-beta?

The bands in question fall on the smaller end of the meso-beta scale. We have updated the manuscript to note the typical length scales in both the short and long axes. The referenced papers collectively document the spectrum of sizes of these bands (both the larger primary bands and the smaller multi-bands) in exhaustive detail.

At what was Line 28 and is now Line 39 we added the sentence, "These bands are typically a few tens of kilometers along the short axis and < 200 km along the long axis.".

Line 58: are you results sensitive to the 0 dBz threshold used for removing noise?

It is necessary to dealias the observed radial velocities prior to the wave detection step. We apply the 0 dBZ threshold as a pre-processing step on the WSR-88D data since we found that removing the low-reflectivity-value data greatly improves the results of the automated radial velocity dealiasing function (from the PyART library) and produces a less noisy and easier to interpret radar data field.

If a user wanted to apply this method to cloud radar data where the sensitivity of the radar is better than the S-band WSR-88D radar, filtering out values below 0 dBZ would not be a desired step. We have added a sentence pointing out the threshold value is an instrument/application choice at the end of the first paragraph in the Conclusions section.

At what is now Line 293 we added the sentences, "Specific filtering thresholds for such instruments should be selected consistent with instrument specifications and intended application. Processing of radar observations with different dynamic ranges and noise floors than a WSR-88D radar will likely use different threshold values."

Line 233: It will be good to mention the native resolution of the scanning KaSAPR. Thanks. Less than 200 m sounds vague.

It was not our intention to be vague. Being a research radar, KASPR is often run with different settings. We gave a representative value since the resolution is partially a function of range from the radar since the beam spreads with distance. The resolution is also determined by the length of the range gates which itself is a function of the maximum range of the radar and the number of gates used. We have updated the manuscript to note the half-power beamwidth of 0.32 degrees, the number of range gates (1154), and the length of the range gates (24 m) applicable to the cases we have used in the manuscript.

At what is now Line 242 we altered the sentence to read, "The KASPR radar has a narrow beamwidth (0.32°) and, for this case, a range resolution of 24 m for 1154 range gates yielding a maximum unambiguous range of 29 km.".

Line 272-273: I understand the reasoning behind not classifying the hurricane rain bands as gravity waves, but shouldn't they have a larger wavelength than the mesoscale (~20 km) ? This might provide an objective way to discard them.

In this specific case, the length scale of the velocity bands is similar to the winter storm cases. We agree that in some situations that the length scale of the velocity perturbations can be used to constrain what the potential wave types are.

Figure 1, 2, 5, 6 and 8 are missing some of the axis labels.

The figures in question as well as Figure 7 have been updated to add axis labels.

Figure 3 caption mentions upper and middle panels, but the figure only has two rows. Something is missing here.

The caption has been corrected.

The caption for Figure 3 was changed from, "The solid black lines denote the span of the cross sections shown in the upper and middle panels..." to, "…The solid black lines denote the span of the cross sections shown in (a) and (b)…".