

Atmos. Meas. Tech. Discuss., author comment AC2
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Reply on RC2

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.,
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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.

The manuscript describes a method to detect wave like features in Doppler velocity radar data. The analysis is based on low elevation PPI scans as well as RHI scans. The impressive simulations and the examples show the functionality of the algorithm. The animations provided in the supplement are a great help to understand the situation. The manuscript is well written and deserves publication.

However, and this is my main criticism, I feel slightly unsatisfied since the manuscript describes only the very first (but of course important) step towards (automatic) detection of wave features. The authors do outline this point in the conclusion and have good arguments, but I would feel more convinced from the manuscript if for one of the examples additional steps could be shown. Especially since they admit that in one example wave features in are easier to locate in the difference plots than in the binary detection plot (lines 251 – 255).

So far, we have not found a best way to automate detection. An exploration of how to automate the detection of waves and calculation of velocity band motion will fall down a rabbit hole of exploring image processing techniques. Possible approaches include: 2D wavelets, 2D FFTs, texture analysis, and neural networks. Determining a good enough approach is application and data dependent. Exploring this topic in satisfying detail is beyond the scope of this paper and is a potential candidate for a follow up paper.

Minor remarks:

Line 41: how to see vertical motion in low level Doppler data?

Vertical motion is a very small component of radial velocity in low-elevation-scan (0.5 degree elevation angle) Doppler radar data. Vertical motion can be inferred from convergence patterns in the data. Vertical motion observations are not required for wave detection but are needed to confirm the quadrature relationship.

Line 43: somehow this first sentence should be given much earlier. Radar is mentioned already in the beginning of the introduction.

This paragraph was moved to earlier in the paper to what is now Line 23.

Line 50: precipitation fall speed is only relevant when elevation is high. You should mention that Ottersten and Stober use vertical pointing radars.

Stober et al. (2013) made use of the MAARSY radar in Norway which is a vertically oriented phased array radar. They used high elevation angle data and then derived the horizontal wind field using VVP and VAD techniques. The sentences that started on what was Line 44 now start on Line 25 and read, "Stober et al. (2013) used horizontal wind observations derived from high-elevation scans from a vertically oriented phased array radar to detect and measure the properties of gravity waves in the upper atmosphere from 75 to 100~km altitude."

Ottersten et al. (1973) is a review article which describes the results of several radar studies. Some of the radars described are noted as having "steerable antennas" and the paper include examples of time-height plots from vertically pointing radars as well as RHI examples from scanning radars. The sentences that started on what was Line 43 now start of Line 23 and read, "For example, Ottersten et al. (1973) describe clear-air radar observations of gravity waves in the troposphere from multiple studies which made use of both scanning and vertically pointing radars."

Line 50: it is tradition to outline the structure of the paper at the end of the introduction.

The manuscript has been updated to include such an outline at the end of Section 1 starting at Line 55. The added text is, "Section 2 describes the method to detect waves and outlines several limitations to the method. Section 3 examines examples employing the wave detection on idealized data. Section 4 examines the use of wave detection on data from a winter storm. Section 5 examines a tropical system where the wave detection method produces output that looks like a velocity wave but is not and Section 6 contains our conclusions. There is a video supplement which includes animated versions of all figures in this manuscript".

Line 64: maybe it's time to mention that in radar meteorology positive Doppler velocity are motion away from the radar. People from the lidar world often use the inverse notation. The analysis would also be interesting for long-range (app. 15 km) Doppler lidars.

Section 2, paragraph 3 has been updated to note the radial velocity sign convention typical to precipitation radar. At what was Line 66 and is now Line 74 we added, "Note that the convention for Doppler weather radar is that positive radial velocity values represent motion away from the radar."

We agree with the reviewer that there is a potential for applying the wave detection method to lidar data through we have not made any tests. Section 6 (formerly 4), paragraph 1 was updated to discussing the potential application for lidar data. The new sentences at Line 291 and reads, "This technique should be extendable to Doppler radial velocities from other instruments such as cloud radar and lidar."

Line 165: mention here that you are using also observations.

The section headings have been changed to make it more clear where idealized data in being used versus real-world data. This is in combination with the added outline

paragraph at the end of Section 1.

Line 172: what is the motion speed? I'm confused: if the waves move to the west, doesn't this imply that there is an easterly background field? Or is there an additional external force, which isn't relevant here, moving the system to the west?

Gravity waves can and often do move in directions different from the prevailing wind. For the single idealized wave example, we prescribed the wave motion as moving towards the west. We set the background wind field to zero to make the depiction of the wave very clear.