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Interactive comment

Interactive comment on "Observing ice particle growth along fall streaks in mixed-phase clouds using spectral polarimetric radar data" *by* Lukas Pfitzenmaier et al.

Anonymous Referee #2

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General Comment: This study collected polarimetric Doppler spectra at an elevation angle of 45 degrees. The observed spectra were realigned with height along with retrieved fall streaks and analyzed the reflectivity and differential reflectivity spectra changing with height to discuss ice particle growth. The novelty technique and idea used in this study are very interesting, but sometimes I was confused by increase/decrease of fall speed when looking at the observed spectra. Because horizontal wind components would be larger than vertical wind components in slant pointing Doppler spectra measurements, it would be good if components of horizontal wind could be removed from each Doppler spectrum plot, so that readers can track growth processes which can be represented by increases/decreases of reflectivity and abso-

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Discussion paper

lute values of Doppler velocity.

Specific comments:

1) I was confused by increase/decrease of fall speed when looking at the observed spectra changing with height. The TARA-observed Doppler spectra include horizontal wind component in addition to particle fall speed component. From the observed spectra (e.g., Figures 7, 11, and 13), it was difficult to see particle growth, which can be represented by particle fall speeds, because the spectra included large components of horizontal wind. I recommend extracting the horizontal wind component from the observed spectra. I think that this is not so difficult because the authors nicely retrieved horizontal wind.

2) Polarimetric variables have an elevation dependency; for instance, Zdr values decrease with elevation angle for horizontally-oriented oblate particles. Particularly, the Zdr values can significantly decrease above an elevation angles of 20 degrees. Did you correct the observed Zdr for elevation angles?

3) Section 4, Figure 3: As the authors mentioned, the differential reflectivity is influenced by particle densities. One example is that aggregation can reduce its density, resulting in decreasing in Zdr (this was mentioned in the text). Another example is that initial riming of branched crystals can increase the density as gaps between branches are filled, resulting in increase in Zdr. I recommend mentioning this effect in the text as well.

4) Section 5: Please explain how to take into account individual particle fall speeds to retrieve fall streaks and discuss particle growth of individual particle populations. Particles included in the radar sampling volume have different fall speeds. In the next range bin, the composition of particles in the volume can be different from that in the previous range bin volume above, because individual particles can have different fall speeds (i.e. size sorting effect). This is true even for retrieved fall streaks. When discussing ice particle growth using Doppler spectra at different heights (Figures 7, 11,

and 13), I think that different particle fall speeds should be considered. Please explain if some assumptions were used in the discussion.

5) P. 8, line 22: There could be non-Rayleigh scattering effect in addition to attenuation.

6) P. 8, line 31 “homogeneous wind”: Does this mean horizontally homogeneous?

7) P. 8, line 32 “shear”: vertical shear?

8) P. 10, lines3-4 “The closer…”: If large particles dominated the total reflectivity, RHOhv may not reflect the particle diversity. In that case, as overall there is little contribution from the non-spherical particles, resulting in high RHOhv.

9) Section 6.1, Figures 6 and 10: What is the minimum limitation value of LDR due to the antenna limitation? In Figures 6 and 10, below Region N, LDR seems to be relatively high (∼-25 dB) at the edges of spectra. LDR tends to be large with low signal-to-noise ratio. What can the relatively high LDR at the edges of spectra indicate?

10) Section 6.1:, Figure 7: Compared to other studies showing S-band polarimetric radar Zdr in dendritic growth zones (e.g., Kumjian and Lombardo, 2017, doi: 10.1175/MWR-D-15-0451.1; Griffin et al. 2018, doi: 0.1175/JAMC-D-17-0033.1), Zdr values in Fig. 7 are relatively small. Why? Is there an elevation dependency?

11) Figure 9: How did the radiosondes measure supercooled liquid droplets? Did they have special sensors?

12) P. 10, line 19: What is the difference between ice particles and snowflakes here? I guess this meant ice crystals and snowflakes (aggregates)?

13) P. 11, lines 6-9: This does not make sense to me. I am wondering why the seeded case showed slower increase in Zh? I think that the ice seeding could accelerate aggregation, resulting in rapid increase in Zh…

14) P. 11, line 17: To me, the spectrum at 3.1 km does not seem to broaden (Fig. 10c). Could you snow a zoomed up plot?

15) P. 11, line 34: Toward 2864 m in Figure 11, sZ values increases, while sZdr kept their values. Does this profile suggest increase in number concentration rather than size? What is the source of nucleated ice?

16) P. 12, line 1: Please mention effects of horizontal wind components. Do the particle populations having Doppler velocity >-8.5 at 3055 m exactly correspond to those at 2864 m?

17) P. 12, line 8, Figure 11: Significant negative values in Zdr were also shown at 3055 m. Could you explain the negative values at this altitude?

18) Section 6.2, P. 12, line 22: I am not sure why the authors identified the Zdr signature as needles/columns and why they decided that the TARA-observed Zdr corresponded to the Mira-observed Ldr. As the authors pointed out, the retrieved Zdr profile and the t_0 profile were inconsistent at the region N in Figure 9. This suggested that the TARA radar measurements and Mira radar measurements looked at different locations and different particles.

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