Review of "Influence of low-level blocking and turbulence on the microphysics of a mixed-phase cloud in an inner-Alpine valley"

By Ramelli et al

General comments:

The authors investigate the influence of low-level blocking and shear induced turbulence on the cloud microphysics. They find associated changes in the cloud microphysics associated. Additionally, a low-level feeder cloud is observed and seems to be caused by the low-level blocking.

This study is of great interest and importance for our understanding of the cloud processes in mountainous regions. I believe this paper can be published after major revisions. I am not sure if I completely agree with the authors' interpretation of radar observations and would like to see more explanations and answers to my questions. Please find my comments below.

Specific comments:

Lines 157-162. The interpretation of LDR (or any other dual-polarization radar variable) is a bit more complex. It is true that LDR depends on an apparent shape of a hydrometeor. However, to make matters more complex, it also depends on the particle refractive index, in case of ice particles the refractive index is related to the particle density. Therefore, increase in the ice particle density, i.e. by riming, may increase LDR. That is why changes in LDR are not necessary indicative of the changes in particle shape (see for example Fig. 2.8 page 65 in (Bringi and Chandrasekar, 2001)).

Another example is the change of LDR in the melting layer of precipitation, it is driven by the changes in the refractive index due to melting and not changes in particle shape.

Bringi, V. N., & Chandrasekar, V. (2001). *Polarimetric Doppler Weather Radar : Principles and Applications*. Cambridge University Press.

Line 237. "an increase in the LDR was observed within the shear layer (Fig. 8e, f), which is indicative of a change in the hydrometeor shape" Actually, to my eye the increase in LDR starts above the shear layer. It may be related to the increase in Doppler velocity as shown in Fig. 10. Such an increase in Doppler velocity may be indicative of riming (Mosimann, 1995; Kneifel and Moisseev, 2020), which affects LDR as well.

Mosimann, L., 1995: An improved method for determining the degree of snow crystal riming by vertical Doppler radar. Atmos. Res., 37, 305–323, https://doi.org/10.1016/0169-8095(94)00050-N.

Kneifel, S., and D. Moisseev, 2020: Long-Term Statistics of Riming in Nonconvective Clouds Derived from Ground-Based Doppler Cloud Radar Observations. J. Atmos. Sci., 77, 3495–3508, https://doi.org/10.1175/JAS-D-20-0007.1.

Line 248-249: “This is in agreement … with the ice particles observed by the MASC at the surface (Fig. 11a).”
Actually, MASC observations do show presence of rimed particles as well.

Line 250: “Below 3000 m, the LDR increased up to -20 dB within the fallstreak (Fig. 10b).”
It is not clear what you are referring to. Please indicate on the spectra which part has LDR values up to -20 dB.

If this is the faster falling part of the spectrum, then it cannot be due to newly formed ice crystals. In this case, in my opinion it would be riming. If the increase in LDR occurs in the slow falling part then it is cause by newly formed ice particles.

Line 254: “An increase in the LDR can be explained by the presence of needles, columns and/or irregular ice particles.”
Do you observe this in Doppler spectra? You should see bimodal spectra, or at least some indication of bimodality.

Line 259 – 261: “If fragile ice crystals such as dendrites or needle-like structures collide 260 with large ice particles within the turbulent shear layer, small ice fragments might break off and lead to the production of secondary ice particles upon collision (e.g., Vardiman, 1978; Yano et al., 2016).”

Of course, it may also be H-M process if the LDR signatures caused by riming.

Line 326-327: “Riming was assumed to play only a minor role, due to the low LWP (< 100 g m−2) observed by the microwave radiometer (Fig. 4c).”

I am not sure if I agree that we can completely exclude riming based on LWP alone. Riming efficiency does not depend on LWP, but on liquid droplet diameter. So, given that droplets are big enough to take part in riming, riming could take place.
We can compute if riming would significantly affect particle properties, by computing rime mass fraction for the observed LWP values.
Let’s assume that we a plate like crystal is formed at the cloud top. Just to have a first guess, we can choose P1a from Pruppacher and Klett.

TABLE 2.4a

Mass-size relationships for various types snow crystals. Data taken on Mt. Teine (1024 m, Hokkaido, Japan), based on data of Heymsfield & Kajikawa, 1987.

Crystal type	Mass-size relation m(g), d(cm)	Diameter range (mm)
C1h	$2.63 \times 10^{-2}\ d^{2.68}$	0.3-0.6
P1a	$3.76 \times 10^{-2}\ d^{3.31}$	0.3-1.5

We can compute the expected FR as (see my simple Matlab code):

```
d = 0.3:0.01:1.5; %% mm
m = 3.76 * (10^-2) .* ((d/10).^3.31); %% grams for P1a

LWP = 50; % g/m^2
```

```
dm  = LWP.*(pi/4).* (d/100).^2;

%%% Rime mass fraction
FR = dm./(m+dm);
```

This computation gives rime mass fraction value close to 1. Of course, I have assumed the riming efficiency of 1, here. So, the actual FR value could be lower. But notice that I have used LWP of 50 g/m^2 and not 100 g/m^2.

If riming is taking place here, even for the observed low LWP values we can expect a significant impact on particle properties.

For more discussion on the effect of riming on snowflake properties, see:

Li, H., Moisseev, D., & von Lerber, A., 2018: How does riming affect dual- polarization radar observations and snowflake shape? J. Geophys. Res. Atmos., 123, 6070–6081. https://doi.org/10.1029/2017JD028186

Moisseev, D., A. von Lerber, and J. Tiira, 2017: Quantifying the effect of riming on snowfall using ground-based observations, J. Geophys. Res. Atmos., 122, doi:10.1002/2016JD026272.