Second Review of

Properties of mid-latitude cirrus cloud from surface Ka-band radar observations during 2014-2017

by Juan Huo et al.

For the second review, I start a new discussuion thread, because it will become too confusing to fill in comments and thoughts again in a different color in the author‘s response document that went back and forth already several times.

The authors have worked on the main two aspects of the first review, but to my opinion not in a completely satisfactory way. That means the paper still needs some improvement before it is mature enough to be published. I will outline this in the comments below concerning the two previously mentioned points and some new comments that appear with the revised version of the paper. The comments are sorted in order of appearance in the manuscript. Note that text copied from the manuscript is in italics and quotes.

1) Line 22: ‚*Cirrus clouds, composed of ice crystals, is ice cloud*.‘

First, this sentence is gramatically not correct and second, it is unclear for what reason the sentence should is placed here. Generally, the new text needs some language polishing.

2) *Lines 26 – 30: ‚Ice clouds exert potential warming effects on the Earth–atmosphere energy system. Studies show that the occurrence frequency of the cirrus clouds, part of ice clouds, exhibits latitudinal variability ranging from 50% in the equatorial regions of Africa to 7% in the polar regions (Hahn and Warren 2007; Sassen et al. 2008, 2009; Stubenrauch et al, 2006).* → see ****** below
Ice clouds are an important component of the planetary radiation budget in terms of magnitude; plus, they influence hydrological and climate sensitivities and affect surface climate (Lawson et al. 2019; Yang et al. 2015).‘

****** Since you also deal with mixed phase clouds, you need to say also something about them at this point.

3) Line 45: please specify the temporal resolution.

4) End of Section 2.1 Ka-band radar: ‚*It should be noted that KPDR is more sensitive to larger particles in the cloud particle size distribution since the reflectivity is proportional to the D6 (D is particle size).‘*

You need to write a sentence here that thin ice clouds containg mostly small ice crystals are not detected!

5) Line 78: ‚*Cirrus is ice cloud‘* This is no sentence → see comment 1)

6) Section 2.2 Ice cloud identification: This section is mostly the same as before, describing the the ice cloud observations as they were all cirrus clouds. This needs to be rewritten to

place it in the context of ice cloud observation at temperatures < -10 C and then define that those at < -38 C are cirrus.

7) Line 169-170: *‚Both the maximum CTH (13.35 km) ...‘*

In line 167 the maximum was defined as 12.9 km.

Does the followign values need to be corrected ?
‚ … and the highest mean CTH (10.16 km) are found in summer, whereas winter has the minimum CTH (11.25 km) and lowest mean CTH (7.66 km).‘

8) Table 1: all values have slightly changed, why is that ?

9) Figure 4 (and respective text):

The maximum cirrus optical depth is reported to be between 1-3, e.g. Sassen et al., 2008; Kienast-Sjögren et al., 2016. In your Figure 4, COD up to 20 is seen, pointing to the glaciated mixed-phase clouds that you have detected. You write in lines 224-225:
‚The proportions of CODs lower than 3 in spring, summer, autumn and winter are 46%, 36%, 49% and 52%, respectively.‘
If this portion of ice clouds is at the lower temperatures, then these are probably in-siu-origin cirrus clouds. This could be mentioned in the text.

10) Lines 263-264: *‚At temperatures higher than −38 C, ice clouds can form heterogeneously or homogeneously (Kanji et al. 2017).‘*

This is not correct. At temperatures > −38 C, ice form solely heterogeneously from liquid cloud drops. In case liquid cloud drops are supercooled down to = -38 C, they freeze homogeneously at this temperature. I‘m sure that this is correctly described in Kanji et al. (2017).

11) Line 291: *‚... until they are lifted to the ice formation temperature region.‘*

… Until they are lifted to temperatures < -38 C.

12) Line 300 (and Figures 8-11):

First I want to mention that the new plots are really very intersting!

But:

‚… central temperature of −65C, −60 C, −55 C, −50 C, −45 C and −40 C...‘

In Figure 6, the lowest detected temperature is -50 C, and in the previous version of the paper, Figure 8 and 9, the lowest center temperature was - 45 C. Where does the new data below -45 C come from ?

(Side comment: I do not understand that you argue in the author‘s response that *‚-65 C temperature occupy very small percent of the temperature range‘* (your Figure RC6) to explain that there are no cirrus clouds at temperatures < -50 C in your observations – and now such cirrus are presented.

One major comment in my first reviews was that cirrus < -50 C are not present in your data set. But, as the coldest point at mid- latitudes is around – 65 C, absence of these cold, thin cirrus means that they are not detected. We discussed that back and forth and now such cirrus appear …)

– Anyhow, the database is not consistent now, the data at temperatures < -50 C should be added to the observations shown in Figures 5 and 6 for warmer temperatures. Are they included in the analysis shown in Figures 1 – 3 and Table 1? If not, this should also be done.

– Also, in the panels of Figures 5 – 9 the number of data points (or hours of observations) should be noted to give an imprsssion on the statistical significance of the observations.####ol

13) Figures 8-11: In the Figure captions is would be good to note in addition that the dashed lines should correspond to in-situ-origin and the dotted lines to liquid-origin.

14) Figures 8-11: The PDF's at -45 C and -40 C look very different (much smoother, no modes) than those shown in Figure 8 of the previous version of the manuscript – why is that ?

15) Lines 308 ff: The results are very intersting, but mainly only described in the text. It would make the paper scientifically more sound if some ^explanations for the discovered features could be offered. Here are two examples to demonstrate what I mean, but there are more places.

- *'There is no cirrus cloud detected in summer and autumn below −65 C.'*

- In Figures 9 and 10, there are no cirrus clouds below -60 C !
- Could this be because the troposphere is higher in summer and autumn because of higher sun intensity, so the highest and coldest cirrus are not detected?
- The higher sun intensity in summer, causing more convective active, would also explain a higher percentage of liquid-origin cirrus.

- *'Above −55 C, the peak frequency center in winter locates at smaller reflective value than that in summer.'*
What does that mean physically for the cirrus ?

All in all, the results are sound taking into account the underlying processes (which is great), so it would improve the paper to discuss that.