Exploiting airborne far-infrared measurements to optimise an ice cloud retrieval by Panditharatne et al.

This is an interesting and valuable work. It describes the first retrieval of the cloud parameters, including optical depth, effective radius and top height, along with the atmospheric profiles of temperature and water vapour from up-welling far-infrared spectral radiances. In this work the RAL retrieval scheme, introduced in previous works, has been applied to the spectral radiance measurements performed with two spectrometers: the Tropospheric Airborne Fourier Tranform Spectrometer (TAFTS), operating in the far infrared (FIR) portion of the spectrum between 80-600 cm-1, and the Airborne Research Interferometer Evaluation System (ARIES) operating in the mid infrared (MIR) between 550-3000 cm-1. These measuremenets were performed on board of the aircraft B895 which flew in 2015 as part of CIRCCREX campaign. Carrying on board several instruments for cloud and atmosphere characterization, such as a series of three probes or CPIs and a backscattering/depolarization lidar to assess the cloud particle habit/size distributions and the extinction coefficient along with Vaisala probes providing information about humidity and temperature. The availability of such in situ measurements allowed the comaparison with the retrieval products. The results show in generally a good accordance but also point out on the necessity of a refinenement of the currrent ice optical properties in models particularly in the FIR. Furthermore, it is shown the improvement in the retrieval performance by using the FIR portion with respect to neglect it, in particular in distinguishing the different crystal habits.

The manuscript is well written and structured even though some minor revisions need to be addressed before publication. I also suggest few corrections to enhance the clarity:

Abstract: line 5 ":with and without the far infrared.." → "including and neglecting the far infrared portion of the spectrum.."

line 17: "..cover.." → "..cover permanently.."

line 54: "This work" → "The present work.."

Section 2.2

Please, can you structure the initial part of the section by listing the in situ instruments present on board for cloud characterization, describing briefly what

they provide? I think it is more simple for a reader to follow the text having the scheme in mind.

You say that the extinction coefficient profile obtained from lidar signal in Fig. 2a is not reliable for deriving optical depth due to calibration issues; if you don't use it to calculate the COT, maybe, this is a little bit misleading, wouldn't be better to show the raw signal?

Regarding this, the COT calculated in Eq. (1) with the new method, is it obtained using the raw signal? I mean, are the Patt and Pref raw signals? Maybe it is better to report this in the text. If so, this is a reason to show the raw signal. in Fig. 2.

However, how much the COT differ from that one calculated from the extinction profile? By eye, it does not look too far from the value you found, if we multiply the thickness for the mean extinction, but maybe I'm wrong. How the extinction coefficient has been derived from the backscattering signal?

The extinction due to the molecular contribution is already considered in the new method?

Caption Fig. 2: please indicate that are dashed lines.

Fig. 2 : the blue lines shouldn't be dashed?

I would suggest , if possible, to show some pictures of the habit and size distributions provided by the CPIs. It is just a suggestion because it would be very interesting to see the in situ measuremenets of the ice crystals inside cirrus. And of course, I think, it would be an added value.

<u>Section 2.2.1</u>

Line 145: can you indicate the size range of the dominant smaller crystal?

Can you show which parameters are fitted of the PSDs and report some results of the fit? Or briefly explain the procedure?

Line 148: "..the habit and.." → "..the habit type and.."

Line 148: "..CPI measurements habit recongnition.." → "..CPI measurements by applying habit recongnition.."

Can you report, if possible, a numerical example of the habit fractions derived from CPIs by applying the recognitional algorithm?

Section 2.3.1

Line 186: with “remove” you mean deconvolved?

Line 191 and 193: Just remember that are available more recent version of LBLRTM and, in particular, of continuum MT_CKDv3.8

Line 199: “..using the Masuda model above 769cm-1” → “..using the Masuda model above 769cm-1 since the radiometric measurements were performed over the Ocean” (Is it correct? If so I would clarify why the Masuda model has been used)

Line 203: “and the GHM model” → “assuming the GHM model”

Fig. 4: The differences of TAFTS in blue are not visible, would be possible to expand the scale just for this plot of TAFTS for example in logarithmic scale to make it more readable?

Section 3

Could you indicate what is the initial guesses or if they are equal to a-priori?

Which are the correlation lengths used for a-priori atmospheric profiles?

Eq. (7) the differential dz is missing inside the integral.

If you fit the CTH how much did you fix the geometrical thickness?

Line 431: maybe you mean “..increase from 0.9 to 1.0”? not from 0.9 to 0.1