EGUsphere, referee comment RC1

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Comment on egusphere-2022-1217

Matthew Lebsock (Referee)

Referee comment on "The classification of atmospheric hydrometeors and aerosols from the EarthCARE radar and lidar: the A-TC, C-TC and AC-TC products" by Abdanour Irbah et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-1217-RC1, 2023

This paper describes the target classification products for EarthCARE using lidar, radar, and synergy lidar and radar algorithms. The paper provides a needed reference for the at launch algorithms for EarthCARE. There are elements of the paper, which are written, in too general a fashion. The specific instances that I noticed that require more detail are listed below. In general, only minor revisions are required to this manuscript.

Line 19: Nobody outside of EarthCARE knows what the Halifax scene refers to. Provide some description of what the Halifax scene is – i.e. a cloud resolving simulation.

The explicit reference to the ``Halifax scene'' has been removed. The sentence now reads: "Simulated EarthCARE observations based on combined cloud-resolving and aerosol model data are used to test the processors generating the target classifications."

Line 104: What is the Beta threshold?

Note that this section has been rewritten and more detail has been supplied in general, including simplified decision tree figures. A separate threshold for the troposphere and stratosphere can be specified. These thresholds are currently set to 1.0e-m/sr but these values and perform well for the current tests scenes. It is expected that they will be updated on the basis of actual observations made during the commissioning phase. The current value does perform well for the considered test scenes.

Section 2.2: How are the layer integrated depol and attenuated backscatter used? Thresholds? If so what are they?

The layer integrated depol and attenuated backscatter are used in the same way as described in Hu et al 2009. That is, the region where a layer is located within layer integrated-backscatter-depolarization phase space determines the phase assignment.

Line 146: Describe the median filter resolution.

The median filter resolution is adjustable and is expected to be updated on the basis of commissioning phase observations. For the simulated tests scenes a resolution of 11 JSG pixels (about 10 km) along-track and 3 vertical pixels (about 300 m).

Line 162: use actual CloudSat and CALIPSO references:

These reference have been added and used

- Marchand, R., Mace, G. G., Ackerman, T., & Stephens, G. (2008). Hydrometeor Detection Using Cloudsat—An Earth-Orbiting 94-GHz Cloud Radar, Journal of Atmospheric and Oceanic Technology, 25(4), 519-533.
- Mace, G. G., and Zhang, Q.(2014), The CloudSat radar-lidar geometrical profile product (RL-GeoProf): Updates, improvements, and selected results, *Geophys. Res. Atmos.*, 119, 9441–9462, doi:10.1002/2013JD021374.

Line 195: Is the reflectivity attenuation corrected?

The CPR reflectivity that is used as input to the synergistic target classification is corrected for gaseous attenuation, not hydrometeor attenuation.

Line 219: Add () around H.
Corrected

Line 225: change 'no' to 'non

Corrected

Line 235: '*The observed pixels above land and below 3 km altitude with reflectivity between -20 and -15 dBZ and temperatures not lower than 15 °C are classified as insects and/or artifacts.*' I don't understand why these couldn't be fair-weather Cu. Can you explain?

We agree with the reviewer that in terms of radar reflectivity value, it is possible to be a continental fair-weather cumulus cloud. However, there is a significant volume of past research conducted at the DOE ARM sites that clearly indicates that most radar echoes over land during warm seasons is due to insects (Luke et al., 2008; Chandra et al., 2013; Kollias et al., 2014; Lamer and Kollias, 2015). This experience explains our suggestion to classify these echoes as insects. Please not that when the temperature is lower than 15 °C, the CPR echoes are classified as liquid clouds. Here is the revised sentence in the manuscript:

"Over land and when the air temperature is not lower than 15 °C, there is a significant record of observations from profiling millimeter wavelength radars (cite: Luke et al., 2008; Chandra et al., 2013; Kollias et al., 2014; Lamer and Kollias, 2015) that suggest that most of the radar echoes are from deep insect layers. Furthermore, because if non-Rayleigh scattering, the insects radar reflectivity is typically below -20 dBZ. Based on the above information, all CPR echoes over land and below 3 km altitude with reflectivity lower than -20 dBZ and temperatures not lower than 15 °C are classified as insects."

Luke, Edward P., Pavlos Kollias, Karen L. Johnson, and Eugene E. Clothiaux. "A Technique for the Automatic Detection of Insect Clutter in Cloud Radar Returns", Journal of Atmospheric and Oceanic Technology 25, 9 (2008): 1498-1513, accessed Jan 23, 2023, https://doi.org/10.1175/2007JTECHA953.1

Lamer, Katia and Kollias, Pavlos, 2015, "Observations of fair-weather cumuli over land: Dynamical factors controlling cloud size and cover" Geophysical Research Letters Vol. 42, No. 20, pp 8693, 00948276

Chandra, Arunchandra S., Kollias, Pavlos, and Albrecht, Bruce A., 2013, "Multiyear Summertime Observations of Daytime Fair-Weather Cumuli at the ARM Southern Great Plains Facility" Journal of Climate Vol. 26, No. 24, pp 10031, 1520-0442

Kollias, Pavlos, Jo, Ieng, Borque, Paloma, Tatarevic, Aleksandra, Lamer, Katia, Bharadwaj, Nitin, Widener, Kevin, Johnson, Karen, and Clothiaux, Eugene E., 2014, "Scanning ARM Cloud Radars. Part II: Data Quality Control and Processing" Journal of Atmospheric and Oceanic Technology Vol. 31, No. 3, pp 583, 1520-0426

Line 275: I can't track the claim that the radar will only see effective radii > 15 micron. If you look at Eq 5 in Matrosov et al., 2004, we see that assuming a log-normal DSD an expression for effective radius is r_e = aZ^(1/6) with a = (2exp(0.5sigma*N^(1/6))^-1. Plugging in the reasonable values of sigma = 0.38 and N = 100 cm^-3, and radar sensitivity of Z = -35 dBZ, I get r_e = 5.6 micron.

- Matrosov, S. Y., Uttal, T., & Hazen, D. A. (2004). Evaluation of Radar Reflectivity–Based Estimates of Water Content in Stratiform Marine Clouds, Journal of Applied Meteorology, 43(3), 405-419.

The second referee also has a comment on this point concluding that it could be the subject of a long debate:

"I cannot track the r_min_eff > 15 microns as sensitivity threshold. In contrast to RC1, I would expect r_min_eff to be even higher in reality since most dBZ_min estimates are considered without Doppler broadening (see Mech et al 2014). The mentioned -35 dBZ is also only valid for the 10 km averaged product. I would refrain from giving numbers here since this discussion is worth its own paper."

We have therefore decided to delete this sentence since the main information on the sensitivity of radar and lidar to particles has also already been presented in the article.

Line 282: Is 'traduced' meant to be 'introduced'?

Line: "Each co-located pixel of the CPR and ATLID measurement profiles is attributed to a given class of Table 4 according to the probing properties of the instruments **traduced** in the decision matrix shown in Figure 2."

Is replaced by: "Each co-located pixel of the CPR and ATLID measurement profiles is **assigned a** class of Table 4 according to the probing properties of the instruments, **resulting in** the decision matrix shown in Figure 2."

Sections 4.5 and 4.6: Because the radar footprint is much larger than the lidar footprint (Across track) there may be instances where the radar detects a cloud edge that does not fill the radar footprint and is undetected by the narrower lidar beam. It seems the decision tree discounts this possibility.

There will be such instances, but mainly they will occur at cloud edges, where the radar may detect the cloud for a maximum of one extra pixel at the beginning and/or end of a series of cloudy points. It is not true that the decision tree discounts this possibility: it can be seen in the top row of Fig. 2 that in such a situation the lidar-only "A-TC" classification would report either "0 Clear" or one of the various aerosol types. Looking down these columns we can see that if the radar-only "C-TC" classification sees ice or snow then this will correctly be fed into the combined AC-TC classification product. If the radar sees a signal warmer than the freezing level that is not seen by the lidar then if the lidar saw nothing it would be interpreted as insects, while if the lidar detected aerosols then the aerosol properties would be passed into AC-TC. Thus, the only possible mis-classification occurring in the situation identified by

the reviewer would be in this example of insects being reported, but it would only occur in isolated pixels, most likely at the edges of clouds. During the satellite commissioning phase the products from EarthCARE, including AC-TC, will be examined in detail, and if this emerges as a problem then a slight adjustment will be made to the algorithm to correct it, for example replacing isolated reports of insects with clear sky.

Line 327: I have no idea what this sentence means: '*Concerning the clutter situation, it essentially relies on a specific processing of the radar reflectivity signal coming from areas assumed to be close to the ground. It will therefore be treated thanks to the obtained results and reported here using C-TC.*'

This sentence has been reworded as follows:

"Concerning the radar surface clutter region, it essentially relies on a specific processing of the radar reflectivity signal coming from zones assumed to be close to the ground. The C-TC classes resulting from this processing will be taken as such for this region."

Figure 3: Several things about this figure bother me. (1) There is something wrong with the radar noise in the top left of the panel F, (2) can you add two panels to separate the cloud/precipitation from the aerosol in panels A and B, (3) The labels are very small and difficult to read.

This figure will be re-worked, and the reviewer's suggestions incorporated.

Line 366: 'low resolution' has not been defined anywhere. Nor has medium or high.

This will be added to the text. High resolution is 1-km, "medium" and "high" are configurable and currently set to about 50 and 100km respectively.

Line 385: I don't think the other two test scenes have been described in Section 5. Please provide some description.

A short segment of text will be added guide the reader e.g.

"In this paper only results for the "Halifax" scene are presented. AC-TC has also been applied to the "Baja" (which crosses western Canada, U.S. and the Baja peninsula) and "Hawaii" (tropical pacific) scenes [see "The Generation of EarthCARE L1 Test Data sets Using Atmospheric Model Data Sets", Donovan et al., in the same EarthCare special issue of AMT]. Results for these other two scenes are presented within a wider evaluation context within [see the evaluation paper in the same EarthCare special issue of AMT].