Review of “The EarthCARE lidar cloud and aerosol profile processor (A-PRO)”, Donovan, van Zadelhoff and Wang

General Comments

This manuscript describes retrieval algorithms which will be used to process data from the ATLID lidar, to be launched soon on the EarthCARE satellite. Thus this is an important paper which will draw considerable interest. The manuscript gives a good summary of how the retrievals are performed but is unclear in places. There is some necessary context that is missing and some discussion of why key algorithm design choices were made would be helpful.

This paper is one of a large set of EarthCARE algorithm papers and the algorithm described here uses results from several algorithms described in other papers. The current manuscript seems to assume the reader is familiar with these other algorithms. To avoid the need to refer to other papers to understand the A-PRO processor the authors should add brief descriptions of the other algorithms and the parameters which are used as inputs to A-PRO. For example, the paper needs a paragraph or so describing the A-TC algorithm and the classification information it provides to the A-PRO processor, perhaps in the form of a table listing the target categories.

To make it easier for the reader to understand the three ATLID signals used in these retrievals, the authors should include a schematic of the optical layout of ATLID, which isn’t described well by the layout in do Carmo et al. A lidar expert can derive the optical layout from Eqns 1-3, but this requires expertise and some effort. Including a layout schematic would avoid confusion and mis-interpretation.

Retrievals are performed at different horizontal resolutions. It’s not clear to me how the signal averaging and retrievals are related or how results are reported in the data products. In CALIOP data processing, layers in a given scene have likely been detected at different resolutions, following a detect-remove-reaverage approach. It looks like ATLID takes the approach of averaging the entire scene at a uniform resolution, except that certain features are excluded from averaging. Some discussion of how the averaging scheme is similar or different from the one used for CALIOP would be helpful.

Retrievals are performed at 1-km and 50km scales. What was the thinking behind two, and only two, different scales vs. the CALIOP approach which uses five different averaging scales?

It is not entirely clear to me how smearing of aerosol and cirrus together is avoided in this multi-resolution scheme. Dense cloud is easily separated from aerosol (using information from A-TC?) but aerosol and cirrus can have similar scattering strengths, and sometimes even similar volume depolarization. A little description of the information coming from A-TC would be helpful – a table listing the different feature categories? Are A-TC classifications provided at the resolution of the JSG grid?

I was confused by the choice of math symbols in Sections 2.2-2.3. They are different from what I am used to and involve a variety of confusing sub- and super-scripts. Adding a table defining each symbol would be helpful.

Several times it is mentioned that an algorithm parameter is configurable or can be set to one of two or more options. Will one of these options be selected for all operational processing, or is one option or another selected by the operational processor depending on which is better for a given scene?

Specific comments

Line 43 – Please cite the papers which describe calibrations and cross-talk corrections. Maybe add a few sentences on the general approaches for calibration and cross-talk corrections?

Parts of Section 2 read like a bulleted list rather than a narrative. Some additional context is needed to understand the details provided. See next comments.

Line 83 – Describe the JSG a little bit – why is there a JSG? Explain why the L1 ATBs need to be rebinned to the JSG grid. What is the resolution of the JSG?

Lines 85-90 – It's not clear if cloud phase and aerosol type information are determined in A-FM or in A-PRO. Add a table listing the feature mask classifications provided in A-FM?

Line 125-126 – Expand a little on what the A-FM feature probability indices are. I can guess what is going on here, but the reader shouldn't be forced to go to another paper to understand this.

Line 129 – How is the "strong feature" mask created by thresholding? A little more detail please. Is a constant threshold used, is it adapted depending on signal SNR?

Line 134 – The threshold is set to "8" – 8 what? Is this a 355 nm scattering ratio threshold?

Line 141 – It is not clear what is meant by "layering structure" and how this is determined. Is this just feature detection or does it include identifying cloud and aerosol, or determining composition differences? What makes this preliminary?

Line 141-142 – Incomplete sentence (The scattering ratio calculations performed … )

Line 145 and following – It would be nice to have some detail and a figure describing Step 3

Line 151 – Does "e.g. 5" refer to a scattering ratio? If so, this should be made clear, and remind the reader that this is a scattering ratio at 355 nm as some of us think of 532 nm by default.

Lines 152-160 – Understanding what is going on here involves a lot of guesswork. A figure might help.

Line 185 – Is there a definition of fine and coarse layers? It is not clear what the difference is, or why this is done in two steps.

Line 201 – Explain what the 'classification priors' are and where they come from. I think this is the first mention.

Starting around line 243 – does 'a priori errors' refer only to random errors or both random and bias errors?

Lines 225-226 – Is there a subscript missing? Eqn 9 has x^l_a and x^l_r. x^l_a is discussed in the following text but there is no discussion of x^l_r, only of x^l.

Line 243-250 – I don't quite understand how errors are treated in the O-E retrieval. In A-EBD, errors are assumed to be uncorrelated. A constant value of lidar ratio and particle size is retrieved for each layer, but there is still an error which may be different in every range bin. Wouldn't bias errors be highly correlated within an aerosol or cloud layer? Is this just ignored? A little more discussion would be helpful.

Line 288 – The algorithm seems to estimate both IWC and effective ice particle size using one of two parameterizations from Heymsfield et al. The particle size from this approach is just a parameterized climatological average based on temperature and should not be thought of as a retrieval. This should be made clear to data users.

Line 289 – Why are there two options for estimating IWC? Are both options available to the data user or will a final selection made by the algorithm developers after launch. Please explain.

Line 353: Last paragraph of Section 3.1 – Many people are familiar with CALIOP, which uses the simpler Platt method for correction of multiple scattering effects from cirrus. This is mentioned (very briefly) in Appendix B, but it would be helpful to point out here that the small footprint of ATLID enhances the multiple scattering tail effects relative to CALIOP, which has a larger footprint. From the discussion here, it appears to be much easier to characterize errors due to incorrect MS correction for HSRL than for a backscatter lidar.

Color bars: Some of the color bars used in the figures should be improved. Copernicus journals are now making color-vision deficiency (CVD) accessibility a priority. The color bars used in Fig 7 and 8 are probably good for CVD. The rainbow color bars used in Figs 5 and 6, and others, mix red and green and may be difficult or impossible for those with non-standard color vision to interpret.