

We thank the reviewer for their constructive comments. We have responded to each comment in-line below, and will soon submit the updated manuscript including the changes described below. With the introduction of a flowchart figure (new Figure 2) all Figure numbers after Figure 1 have been moved up by 1.

The method is difficult to follow. A flowchart would be welcomed to give the reader a snapshot of the algorithm step chain..

We are sorry that this was the case. A flowchart with discussion has been added which will hopefully makes the method easier to follow

More importantly, the equations need to be closely revised as they appear to be incorrect and cause confusion

The equations have been checked and we sadly made errors when converting this from word to Latex. We thank you for pointing this out.

Color schemes used in the figures need a complete revision in order to meet the first requirement for figures of the AMT submission guidelines (<https://www.atmospheric-measurement-techniques.net/submission.html#figurestables>).

We have revisited the figures indicated in the comments below and improved these.

Below are listed some specific comments. Line 6: "high" > "low"?

Thank you, done

Line 12: What are the "smoothing strategies" for? What is smoothed?

Additional text has been added to provide context.

"An important goal of the A-FM product is to guide smoothing strategies within down-stream processors e.g. the ATLID profile retrieval (A-PRO) algorithm which directly follows A-FM within the EarthCARE L2 processing chain. Within the A-PRO algorithm, profiles of extinction, backscatter and linear depolarization ratio are retrieved. However, smoothing of the ATLID L1 attenuated backscatter is necessary since the SNR levels present at the ATLID native resolution is generally not sufficient for meaningful retrievals to be conducted. At the same time, to prevent biased retrievals, any smoothing procedure must respect the cloud/aerosol structure and avoid mixing strong features, e.g. clouds, and weak features, e.g. aerosol regions, together. The A-FM product provides the A-PRO algorithm with important information that is used to guide various smoothing procedures."

Line 16: "ass" > "as"

done

Line 17: "0.9" > "90 %" since you are mentioning "a percentage".

Thank you, done

Lines 59-60: Note that the VFM is a product, not an algorithm. The feature detection algorithm used to generate the VFM is SIBYL (Vaughan et al., 2009). The typing found in the VFM is performed by independent scene classification algorithms: the cloud and aerosol discrimination algorithm (e.g., Liu et al., 2009), the aerosol subtyping algorithm (e.g., Omar et al., 2009), and the cloud phase discrimination algorithm (e.g., Hu et al., 2009).

You are obviously correct and this was misquoted in the article. An update has been added.

Line 64: Provide a few information on what A-PRO is intended to do. It is unclear what A-FM provides to A-PRO and what A-PRO do with it.

A description has been added to provide the information

“Within the A-PRO algorithm the profiles of extinction, backscatter and depolarization are retrieved for which the ATLID attenuated backscatter signal-to-noise ratios are insufficient at the observation resolution. Indiscriminately smoothing signals, within A-PRO, will result in incorrect retrievals which do not represent the actual atmospheric state leading to, e.g. an incorrect target classification. The A-FM product provides the A-PRO algorithm with a field of significant detection. This field is used within A-PRO to decide on local smoothing strategies ensuring that strong and weak signals are not mixed and not diluted by smoothing clear sky values.”

Line 68: “These smoothed signals”. Smoothed by A-PRO processor here? Correct, the text has been altered to make clear that this means smoothed data in A-PRO.

Line 75: “NWP” > “numerical weather prediction”

Thank you, added

Line 76: Say what type of signal is the L1b signal.

Added description

Line 79: “FeaturMask” > “FeatureMask”

Done

Line 83: “UV” > “(UV)”

Done

Line 89: “to to” Line 91: “the the”

Done

Lines 95-99: Unclear.

Rewrote the first sentence of section 2.1 to make this more clear

Line 100: What the difference between this “smoothing strategy” and the “smoothing strategies” in later processors?

In this smoothing strategy the only thing of importance is to find coherent spatial structures. For instance this means that areas where strong features were found will be filled in by local estimates of data based on the probabilities next to the strong features. This adding of ‘local averaged data’ would be out of the question when performing physical retrievals like extinction. However in this case it enables to fill in weak features next to strong features. The following algorithms use the resulting mask as their starting point of where they can average data depending on additional rules like local depolarization and/or lidar ratio.

Line 120: Eq. (1): Do the Ps represent attenuated backscatter coefficients or power received by the lidar? The r^2 term should be removed or the lidar constant should be added to the equations for homogeneity.

Thanks for noticing it. You are right the equation is exactly in between the two parameters you mention above. We moved from power to attenuated backscatter in between the ATBD to paper conversion and did this inconsistently. The Ps have been rewritten to Bs to make this more apparent and not related to power.

Lines 146-149: Explain more clearly what does the method consist of (threshold on and averaging of scattering ratio signals).

Lines 146-149 of the original text describes the case where the ATLID signals would

be smoothed without taking into account knowledge of features. This is not done within the ATLID L2 chain at all due to the disadvantages this brings. We rephrased the text to make it more clear.

Fig. 1 top and bottom: Replace the 'rainbow' colorbars by colorblind-safe sequential colorbars (e.g., see <https://colorbrewer2.org>).

Changed both the top and bottom figures.

Line 151: "AOD" and "tau". Define and use a consistent symbol.

Done

Lines 150-152: Describe the 4 panels. Panel 1 is a theoretical feature mask (the truth we want to retrieve?). Panels 2-4 are the ATLID attenuated backscatter signal channels simulated from the feature mask extinction (and including all the expected noises during nighttime/daytime?).

Updated text like suggested

Line 154: "(1, panel 2)" > "(Fig. 1, panel 2)"?

You are correct; added

Lines 173-174: What are the signal smoothing strategies for? Table 1, Value 0: "cleat" > "clear".

Added a comment regarding the smoothing strategies and updated table

Line 205: Provide DEM uncertainties.

The DEM is provided through the ESA CFI ACE-2 dataset with a spatial resolution of 270m. It has an accuracy of greater than +/-16m for the lowest quality pixels well below the spatial resolution of ATLID (~103m vertical)

Lines 211-212: "searching up to 2 pixels above". Surface peak cannot occur below DEM?

It was intended to read from lowest pixel (well below DEM up to 2 pixels above). So surface can occur below DEM. The text has been updated to reflect this.

Lines 216-219: Stress that ALL conditions need to be verified (if so?).

Done

Line 222: "the pixels above the surface is" > "the pixel above the surface is"

Done

Line 233: "within within"

Done

Lines 237-238: How is the noise level estimated?

These come directly from the L1b input data and are not estimated within A-FM.

Line 240, Eq. (3): I suspect several errors here:

"2" missing on σ_s below the square root.

The square root did not extend until σ , however I have ensured that it now written as suggested (extending the square root and introducing "2" for readability).

“S²” > “s²” at the numerator of the exponential exponent.

“sigma_s” > “S – sigma_s” at the integral start.

My apologies, it seems that the conversion from Word (ATBD) to Latex formulae has been messed up on my side in more way than one.

Line 242: “error function” > “complementary error function”. Line 245: “very close to 1”.

Be more specific.

The value used (0.9999) within the EarthCARE runs has been specified in the text. This configurable parameter will be evaluated when real data becomes available in the commissioning phase.

Lines 248-250: Specify the type of signal of the images on which the kernels are applied. Detection probability?

Done

Lines 264-267: Rephrase to make it clear that features are only looked for in Mie and that the procedure is performed to Rayleigh only to define attenuated regions.

Rephrased paragraph to describe the usage of the two signals as suggested

Line 268: “a The”

Reformulated sentence

Lines 271-272: Unclear.

Reformulated sentence

Line 278: “in 1” > “in Fig. 1”? Line 280: “bottom” > “middle”

Fixed

Fig. 3: Use colorblind-safe perceptually uniform colorbars (e.g., see <https://colorbrewer2.org>). Diverging colorbars from the defined threshold would make sense here, meaning Mie could be centered on 34 % and Rayleigh on 40 %. Those thresholds should be mentioned in the figure caption.

Very nice suggestion, thanks a lot. The color tables have been updated to make these colorblind-save with a clear color change at the thresholds used in the Mie and Rayleigh channels

Why are they low values on the top of Rayleigh? Are those regions considered fully attenuated?

This has to do with the relatively low Rayleigh signals and relatively high noise within the channel. Pixels within a profile can not be attenuated if there is no Mie feature above. A sentence has been added to reflect this point.

Is it possible to have no surface flag and no fully attenuated flag in a same profile?

In principle this can happen. The surface flag is calculated before the attenuation and not updated after this

Line 282: “The combination of signals in the co-polar Mie and total cross polar channel”.

Do you mean you’ve tried to apply the procedure on the total channel or on both channels separately and then combining the feature masks? It would be interesting to know why the procedure is not applied on the cross polar channel even with a larger threshold to take into account the molecular contamination (or by adapting the threshold to the expected molecular profile).

The procedure was tested using the forward modelled signals from the EC-scenes and showed lower skill scores when including cross polar signals. Hence the reason for our approach at this moment. We agree fully that it is an interesting idea to keep

the option open for testing this again once real EarthCARE data becomes available. The processor will be updated to make this option configuration parameter dependent so that it is easy testable in the commissioning phase.

Line 287: "The resulting Rayleigh mask (not shown)". Rayleigh mask is simply the blue part (< 40 %) of Fig.3 bottom, correct?

Correct!

"helps identifying" > "identifies" (that the only thing it does, right?)

"those regions". Does it refer to some regions discussed in the previous sentences?

Text has been updated to "identifies the"

Lines 308-313: "four specific user defined iteration steps" and "the useful range of iterations runs from 25 convolutions up to 180 subsequent convolutions". I don't understand.

Updated text which hopefully makes this more clear

Lines 311-313: FM values unclear. Also, were 8-9 detected in the previous section? If so, mention it in Sect. 2.5. Also mention when the -1 value is flagged.

Added to the text and updated the discussion

Fig. 4: Use colorblind-safe colors (not red and green together).

Updated figure

Lines 325-326: "Once the multi Gaussian fit exceeds the noise peak by more than a threshold value (i.e. 8 or 10)". In occurrence?

In probability space

Line 336: "2.6.1" > "2.7"

Updated

Fig. 5: "(filled in contours)". Using a contour function tends to smooth the edges. Since the main goal of this article is to present the feature mask, it would be better to show the true feature mask using a classic pseudocolor plot on the native lidar grid.

Contour lines depicting an extinction of $1e-6$ m⁻¹ is shown in white, which is already the color used for "No retrievals". Use another color, e.g. grey, for one of them.

Replace "Median Stitching" green by another color (e.g. light blue).

Updated figure, using beige for the contour line. This is now Figure 6 in the updated paper

Lines 355-356: Why using contour lines of extinction of $1e-6$ m⁻¹? Why not using the contours of the truth (feature mask of Fig. 1)?

The contour lines follow the extinction fields of the model truth input files as seen in the top panel of Figure 1. The $1.e-6$ was chosen here to reflect the contours of the truth without adding too many overlaying contour lines

Fig. 6: Use colorblind-safe colors (not red and green together).

Updated figure

Fig. 6: Why a limit at $1e-6$ m⁻¹ if there are undetected features with extinction < $1e-6$ m⁻¹?

The idea behind the $1.e-6$ contour line was to provide a quick way to determine the quality of the feature finding.

Lines 381-382: I don't understand. Is this information useful for the study?

The info is indeed of no importance for this work and has been removed.

Fig. 7: Replace the 'rainbow' colorbars by colorblind-safe sequential colorbars (e.g., see <https://colorbrewer2.org>).

Updated Figure

Lines 408-410: Unclear.

Updated text

Line 414: "ot" > "it".

Done

Fig. 9, middle: Use a colorblind-safe sequential colorbar (e.g., see <https://colorbrewer2.org>). Fig. 9: Why there are clear sky flags at S-5?

Lines 469-470: "the two observation sheets are not fully collocated in space". Provide more information about the spatial collocation (e.g., a snapshot with the two orbit tracks).

Updated figure

Line 491: "))-"

Done

Line 494: "0.9" > "90 %" since you are mentioning "a percentage".

Done