Overview

The manuscript provides an overview of the cloud optical/physical algorithm (M-COP) that will be used in processing EarthCARE MSI observations. Retrieved datasets include cloud top properties (temperature, pressure, height), optical thickness and effective radius; cloud water path is subsequently derived from the product of optical thickness and effective radius. The algorithm does not include cloud masking or thermodynamic phase, which are provided by a separate upstream MSI product that feeds into M-COP.

The text provides reasonably sufficient information for those in the cloud imager retrieval community to understand the basic algorithm methodology, radiative transfer modeling and ancillary data assumptions. The algorithm leverages a long heritage, i.e., the algorithm and/or methodology is not new. Therefore, there is low risk that the algorithm's datasets won't be of immediate use and interest to the community soon after the launch of EarthCARE.

While not a novel algorithm, the manuscript is certainly within the scope of AMT and its readership.

Major Comments

1. There are no references for the MSI instrument (or ATLID, CPR) or the EarthCARE mission.

2. Given that this is a heritage-based algorithm, the manuscript lacks sufficient up-to-date references to other similar datasets being produced from global imagers. A literature search is needed to provide context.

L35 paragraph: There are no references supporting "hence … several long-term … data records". Presumably the authors are relying on the preceding references that provided a brief historical perspective but these aren't up to date or complete. There are no reference for the latest/recent products from MODIS (GSFC group, CERES group, European and Japanese groups?), VIIRS (NOAA DCOMP/NCPOMP, NASA CLDPROP), next generation GEO imagers (NOAA ACHA, JMA?, CM-SAF?) imager cloud products.

A related example: a MODIS cloud product is mentioned on L298 without any reference or a statement of data provenance (product name, version, archive site). Similarly, details on MODIS Terra L1B are missing (reference, product name – will indicate spatial resolution used, version, archive). By the way, the text says that Terra radiances are being used but, for the shortwave, the authors should be reading in the reflectance dataset (based on the on-board solar diffuser, the primary calibration); see related comment below under L106.

3. CloudSat/A-Train

L46, L47 sentences are misleadingly negative about constellation flying. Remove the "Drawback …" and later text unless a case is made for why it's relevant to the algorithm and this manuscript.

L46: "susceptible to temporal changes in atmospheric state". When the A-Train satellites were fully functional, the two active sensors were constellation flying within ~15 sec of each other and MODIS Aqua was ahead of them by ~60 sec. What reference is there that suggests constellation flying with these temporal differences compromised science due to atmospheric state changes?

L47: “While it was possible …”. Doesn’t make sense as a follow-on to the preceding sentence. Regarding colocation: “impossible to produce the synergistic CloudSat, CALIPSO and MODIS product with sufficient accuracy”. The reference Kato et al. 2010 does not state this. It’s unclear what CloudSat operations issue is being referring to (no reference) or when it occurred. If it refers to anomalies that happened after the Kato reference (e.g., CloudSat DO-OP mode), this simply points out that hardware anomalies can have consequences, just as they will on EarthCARE.

By the way, an advantage of constellation flying is that the active sensor flight tracks can be offset from the imager track so as to better avoid imager sun glint contamination.

4. Sect. 2.4.2:

L240: *Ltype* supposed to be *Ltyp* (as in L typical)?
L241: subscript *acc* not defined.

I didn’t understand the point of this section or what I should learn from Fig. 2 and Table 2.

The authors didn’t connect the measurement variability to the measurement error Se. *Ltyp* is said to be taken from SEVIRI measurements but where did SNR come from? I had assumed SNR was from a pre-launch laboratory calibration (or perhaps on-orbit by looking at dark/cold scenes) and so can only be used to predict noise if it’s the denominator for the same *L*ty*p* that was used in the SNR calculation.

If the authors can justify keeping the figure/table, shortwave channel radiances should be changed to reflectances so it will have meaning to the readers. The authors converted IR radiance to BT in Fig. 5 for that very reason but still used radiance units in the table.

Minor

• Table 1:

- None of the references cited in the table are in the reference list.
- To what extent is the SZA/VZA and azimuthal resolution capable of resolving cloud glory and cloudbow features in the backscattered reflectance? Does it matter?
- Add information about the cloud particle size distribution/effective variance being used.
- What spectral bands are the cloud LUTs calculated for? The text is vague, seems to use VIS generically to also mean NIR (0.865) for optical thickness information (L61), and then shows an effective radius retrieval using the 1.65 µm channel (Fig. 6) while not specifying what channel is used in other figures.
- Remove two occurrences of “]”
- “a)” footnote misspells angle

• Abstract, 1st sentence: “that” instead of “which”.

• Abstract: Regarding OE and uncertainties, the wording in L88 reads fine. But it’s incorrect to infer in the abstract that OE has an advantage (at least not uniquely) over other solution methods in enabling full error propagation. Ignoring prior uncertainties (not a practical constraint in these type of cloud

retrieval problems), the retrieval uncertainty covariance matrix can be calculated independent of the methodology (e.g., Platnick et al., 2021, *Rem. Sens.*, Eq. 1).

• L17, 18: I didn't understand why that part of the sentence was there. The paragraph speaks to a separate rationale for having cloud retrieval products and could just start with "There is an urgent …"

• L38: "their measurement's principle" – awkward if not grammatically incorrect. Could try "information content" though information is used later in the sentence.

• L47, 48: CALIPSO is uppercase.

• L56: "-35" meaning minus with respect to what? Specify EarthCARE's MLT.

• L61: absorbing is for SWIR (not NIR) using notation from a couple sentences previous.

• L70 paragraph: This is a good place to mention the products that are produced daytime only. Also, worth pointing out here that the cloud mask/phase is provided as input to M-COP.

• L76: The MODIS acronym has already been used. Regardless, definitions not provided in the text for most satellite acronyms.

• L95: "Once both …" re-write. Not grammatically correct with position of commas and "both".

• L97: "was" should be "is"

• L106: Does the algorithm actually use radiance and not reflectance for the shortwave optical retrievals? I would have though MSI would have an onboard solar diffuser that will be used for the primary VNIR/SWIR channel calibration and therefore eliminate the need for E0 spectral irradiance database.

• L112: The Moody et al. is getting a bit old and doesn't account for regional ecosystem changes (either interannual variability or secular).

• L149: DAK calculations are at a single wavelength at the channel center. How broad are the MSI channels? Does a single channel center calculation correctly model cloud radiative properties (especially in the SWIR)?

• L199 and L214 equations aren't necessary. Plenty of references/historic literature with that detail.

• L256+: the author's own notation for effective radius (re) is not being used in this equation and in-line notation. Can remove the "w,i" subscript from r (otherwise optical thickness would also have that notation as it's a joint retrieval with effective radius).

• L273: Does the simulator uses different cloud particle scattering models for ice than M-COP? Different radiative transfer code?

• Fig. 3, L247, 278:

In the figure caption and text, does “error” refer to the OE retrieval uncertainty (if so, that’s what it should be called) or is it the difference between the retrieval and an absolute truth? I think it’s the former but not sure. Please clarify.

The CTT contrast is not enough to infer an obvious cloud phase. Please add a phase plot (could be added to Fig 4 or Fig 5 where there’s room). I realize that phase is not your algorithm but it’s very hard to interpret effective radius retrievals without it.

The caption should explain that the COT and REF retrieval/error are missing in that region because the sun angle is too low. However, L280 says that happens at 60N and it appears that the shortwave retrieval data goes missing at 50N. Please clarify.

Why is CTT error (retrieval uncertainty?) missing north of the Canadian mainland?

• Fig 5a: Shouldn’t the image be masked off at the day/night boundary like the previous optical retrieval images?

• Fig. 6: The ice phase radius differences may be due to ice model LUT differences. What can you say about the size difference expected between the Baum model (Table 1) and whichever MODIS cloud product is being used in the comparison (reminder that the reference is missing)? How does the 2.25 µm channel size compare between the two retrievals? Please answer both in the text. L295: by the way, why isn’t the M-COP algorithm being run by recalculating LUTs for MODIS spectral channels so the comparisons can be more meaningful? Apparently, that uncertainty is a source of concern.

• Fig 7: I don’t see the value in showing every dataset in this figure. Also, the dataset labels are not the same list as in the Fig. 8 legend. Why?

• Fig. 8: Where’s the M-CTT line?

• Fig. 9: What MODIS COT and REF product is shown? Again, no reference. The labels are “optical depth” when they should be “optical thickness” for consistency throughout the text.