

Referee comment on egusphere-2022-1187

General comments:

The manuscript by Feofilov et al. aims to demonstrate the cloud detection capabilities of ATLID including the advantages in contrast to other space borne lidars, particularly CALIOP. The authors show that ATLID will be more sensitive to optically thin clouds compared to CALIOP. This finding is used to build the short-term ATLID cloud climate product. To generate a long-term cloud climate product, however the thresholds are chosen to be consistent with CALIOP in order to merge CALIOP and ATLID observations. It is finally discussed how long ATLID onboard EarthCARE needs to be operated in order to calculate reliable trends in opaque cloud cover, which is assumed to be highly influence by human-induced climate warming.

The manuscript is well written and addresses important aspects for cloud climate studies. I mainly have minor comments and technical corrections and I am convinced that after taken these into account the paper can be published. I would suggest some slight restructuring of the chapters (see specific comments) and some more details in the final discussion (also with respect to the case when there are no CALIOP and ATLID measurements available at the same time). I think it is a very good paper that just needs a bit more work before being published.

Specific comments:

1. The manuscript is structured in 'Definitions', 'Short-term cloud dataset and 'Long-term cloud dataset'. The 'simulated lidar profiles over cirrus and stratocumulus clouds' part is an important input dataset for the full analysis, but it is only a subsection of 'Short-term cloud dataset'. I would therefore suggest to add an additional chapter between Definitions and Short-term dataset called something like 'Simulated lidar profiles', because it is also part of the long-term dataset.
2. I would like to see some more discussion for the case that EarthCARE starts operation later than CALIOP stops. Could be a work around to use some typical cloud scenes characterized by CALIOP and later with EarthCARE to find the same cloud regimes to tune the long-term cloud dataset without intercalibration between the instruments operating at the same time?

3. It is stated that a long-term cloud record can be produced when using a kind of less sensitive cloud detection threshold (based on SR and the attenuated total backscatter) which improves the agreement between CALIOP and ATLID. —> But in that case, you are missing some thin clouds which ATLID would be capable to detect. Could ATLID help quantifying how CALIOP underestimated the global cloud coverage in past datasets?
4. Climate models have large uncertainties as shown in Perpina (2021) —> therefore a long space borne lidar record is essential to better quantify trends and understand the inter model differences. If ATLID cannot fill the long-term gap after CALIOP because it is likely not going to operate as long as CALIOP. How could upcoming satellite missions (Aeolus-2 or AOS) help overcoming this long-term challenge after ATLID? You are mentioning this aspect in L 566, but could go in some more detail.

Technical corrections:

L 1-18: You should try shorten the introduction part of the abstract. The whole abstract is way too long. Parts of the motivation and introduction can be addressed in detail in the Introduction chapter.

L 31: ATLID-ST: Please define. Or do you mean CLIMP-ST?

L 56: clouds properties —> Shouldn't it be 'cloud properties'?

L 106: Rephrase to: "Avoid overestimation of the cloud fraction... "

L 110: Averaging le lidar signal. Should be "averaging the lidar signal"

L 121: optically thinner "cloud". Through the text, you always write 'cloud', but it should be clouds.

L 129: Chapter 2: Definitions (rather Methods? See Specific comment above)

L 199: Rephrase to "Or if it was sampled" ...

L 274: Rephrase to "tropical part of the orbit"

L 320: Voluntarily split the -> voluntarily seems not the write phrase here (maybe better artificially??)

L 329: We set the cloud mask to 1 whenever $IWC > 0$. Shouldn't be the instrument sensitivity be taken into account here? Very small IWC values (< 0.001) could be model specific, but does not represent what the lidar would see.

L 337: Better rephrase to "Fig. 4 and 5. demonstrate..."

Fig. 4: Please improve the labelling. What is CALIOP and what is ATLID becomes not really clear here. (a), (b), (c) and (d) are explained doubled, (e)-(h) are missing. I would suggest to contrast the two instruments, always CALIOP left and ATLID right would make the differences more visible.

L 381: particulate backscatter ?? Particle backscatter is more common, also in Line 383.

L 394: "the detectability "

L 397: "the daytime noise increases the disagreement with the reference cloud dataset". This is unclear what is meant. Increases proportional to the disagreement to the reference dataset...?

L 401: during day and night

L 415: Table 2: What is the end of the caption? It is unclear where the free text continues.

L 539: Any idea what makes the big difference in the observation requirement (with respect to EarthCARE operation lifetime) between IPSL-CM6 and CESM1?

L 575: What would be the required overlap period between CALIOP and EarthCARE for optimal intercalibration? Could Aeolus help overcoming the problems when CALIOP and EarthCARE are not flying at the same time (due to CALIOP and Aeolus operating synchronously and Aeolus having a HSRL lidar more comparable to ATLID than CALIOP and ATLID?)

L 650: probably be helpful is too weak in my opinion! “The results in this study using simulations indicate that a merged dataset between CALIOP and ATLID will provide important information...” would be more sound. In general the final paragraph of the conclusions could be phrased a bit stronger showing the benefit of this study.