

The manuscript by Sven-Erik Enno and colleagues reports lightning statistics from the first year of operation of the new Lightning Imager (LI) on board the Meteosat Third Generation (MTG) geostationary satellite. The capabilities of the lightning imager are clearly demonstrated and placed in the context of lightning observations from ground based lightning detection networks and the Geostationary Lightning Mapper (GLM) on board the Geostationary Operational Environmental Satellites (GOES). It is remarkable to see the larger flash rates arising from the preferential observation of discharges near the cloud tops. The manuscript is extremely well written, logically constructed and the figures are informative and support the text. As a result, I have only very few minor comments that might help to clarify the text for the general readership of EGU sphere.

Thank you for reviewing the manuscript and providing valuable comments. Please find our answers to the comments below. The line numbers in the responses indicate the locations of the updates/changes in the revised version of the manuscript.

- **l31: First optical lightning detection from space was reported by Vorpahl et al., Science, 1970 (doi:10.1126/science.169.3948.8) and Sparrow and Ney, Nature, 1971, (doi:10.1038/232540a0).**

Added both references (line 33).

- **l50. Give a reference to the report on MTG-LI by Fullekrug et al. in BAMS, 2025 (doi: 10.1175/2025BAMSSStateoftheClimate.1).**

Added the reference (line 53).

- **l56: State how the absolute measurement is defined to determine the quoted detection efficiency, especially over Africa.**

Added (lines 60-61) a short clarification on the DE method with relevant references: *“(derived using the Global Lightning Detection network GLD360 (Said and Murphy, 2016) and applying a two-system Bayesian detection efficiency approach described by Bitzer et al. (2016))...”*

Note that we prefer keeping it as short as possible here as, in the same paragraph, there is a reference to the LI performances article, containing detailed explanation of the DE method.

- **l142-145: Offer potential explanations for the consistent features of false detections.**

The sources of LI false flashes are discussed in detail in the LI performances article, and the relevant reference is given in the false flash context in the first paragraph of Discussion

(line 218). However, we now also added a brief sentence to state the main sources of LI false alarms in this article (lines 217-218):

“Such false flashes can originate from different sources, including Read-Out-Noise (RON) of the cameras, high energy particles and space debris transiting in the MTG-LI field-of-view.”

• **l187: Cite Roberts et al., BAMS, 2021 (doi: 10.1175/BAMS-D-20-0290.2), who conducted extensive work on lightning over Lake Victoria.**

Added the reference (line 191).

• **l205&291: Explain why the largest value of the two instruments is favoured when compared to an average value.**

I have to admit that we have never tried to merge LI and GLM data using the average flash density of the two. The reason is that this would obviously lead to unnaturally low (detection efficiency) values along the edges of the field-of-view of both instruments. For example, say that we have a grid cell near the edge of the LI field-of-view where GLM observed 50 flashes and LI only observed 10 flashes. From these two numbers we can assume that there were actually a bit more than 50 flashes in that grid cell (as GLM can also miss some flashes). Now, the maximum of the two instruments will be 50 flashes in that grid cell, not very far from the truth. However, the average of the two instruments would only be 30 flashes in that grid cell, i.e., a major underestimation (or low detection efficiency). We tried to capture this idea in a single sentence that was added to the discussion (lines 302-304):

“Selecting the highest value in each grid cell provides a simple filtering criterion, ensuring that the flash density measurement from the instrument with the highest detection efficiency in that cell is retained in the final merged map.”

• **l230-231: Explain how this heightened sensitivity toward in-cloud lightning is determined.**

We don't have yet a quantitative study comparing LI detection efficiency cloud-to-ground vs cloud flashes. However, the fact that LI flash density is so much higher than EUCLID flash density together with the very high EUCLID cloud-to-ground flash detection efficiency clearly suggests that (vast) majority of LI detections are cloud flashes. Tried to clarify this better by adding the following sentence (lines 236-238):

“Given the 3–6 times higher MTG-LI flash density compared to EUCLID cloud-to-ground flash density and the fact that EUCLID has been shown to detect >95% of cloud-to-ground

flashes (Schulz et al., 2016), it can be inferred that the majority of LI observations are associated with IC flashes.”

• **Fig. 1 caption: State whether the field of view shown is corrected for the parallax limitations described earlier in the manuscript.**

This is the pure theoretical field of view, therefore, added a clarification to the caption: *“...without considering the parallax correction effects described in the text...”*

Overall, a highly anticipated publication that is enjoyable to read and which is very likely to become a standard reference for all the future work on satellite based lightning observations over Europe and Africa during the next ~20 years. — Martin Fullekrug

Thank you again for your valuable contribution.

I find the manuscript very well written and scientifically solid and extremely relevant regarding the usage of MTG-LI data in future studies. I have only some minor comments and some typo-related points, which the authors can take onboard if desired. The only critic I have is that the authors do not include much about the limitations of MTG-LI: especially, LI does not classify flashes to cloud-to-ground vs. intracloud, which poses limitations for the data usage in applications/purposes where CG data is needed (see also my comment #7).

Thank you for reviewing the manuscript and providing valuable comments. Please find our answers to the comments below. The line numbers in the responses indicate the locations of the updates/changes in the revised version of the manuscript.

1. Line (L) 22: You say "Global systems miss most of the intra-cloud lightning ..." --> I know this is the case, but could you provide a citation for this as you provide for the continental systems in the next sentence?

Added a good reference for ATDnet IC and CG detection efficiency (line 24).

Also, in the next sentence you say "... detecting a fraction of IC...": can you say what this fraction is? In our ground-based LLS with the current settings the percentage of IC-labeled flashes in the data is about three times the amount of CG flashes, which sounds more than just a fraction.

We agree that "a fraction" might be a bit misleading here. Therefore, changed the sentence to make the statement more quantitative and indicate that at least in some cases such systems can detect a considerable amount of cloud lightning (lines 24-26):

"Continental systems are more sensitive, e.g., NLDN is capable of detecting more than 50% of IC lightning in some storms in its core region (Murphy et al., 2014; Murphy and Nag, 2015)."

2. L27: Note, that only GEO-based sensors provide consistent, uniform and continuous coverage. Maybe to revise: "Space-based geostationary lightning sensors..."?

Changed to *"Space-based geostationary lightning sensors..."* as suggested (line 28).

3. L59: "...during from..." --> should this be just "...from..."?

Corrected the typo, removed "during".

4. L85: "...available AT the link..."

Corrected the typo.

5. L86: SEVIRI jumps up here the first time, should all readers know what this is?

We think this can stay as it is as the end of the same sentence provides a relevant reference where SEVIRI and the cloud top height product are explained in detail. The main message (that LI parallax correction uses real monthly cloud top height climatology rather than a static assumption) can be understood even without knowing the SEVIRI instrument.

6. L127: "...Italy still..." --> I don't get this "still" here? Could you just say "... in the northeast of Italy is 44 flashes..."?

Modified the sentence "still" => "had" (line 131)

7. L223: "This is significantly higher than 6-8 flashes ..." --> The comparison is not fare at all, as to my understanding the EUCLID-based values refer only to CG flashes. To turn this around, with MTG-LI data you cannot actually get the CG flash density values at all, which you should definitely mention somewhere; after all, CG density is the standard parameter e.g. in lightning safety/protection standards.

The main idea of showing how much less ground-based lightning detection systems observed was to demonstrate how much additional information LI cloud lightning detection capability can bring. We tried to make it clearer in the two paragraphs of the Discussion (lines 227-242) by:

- Stating that the EUCLID flash density values are cloud-to-ground lightning only.
- Stating that LI does not discriminate between different types of lightning.
- Adding a reference on the fact that EUCLID can detect >95% of cloud-to-ground lightning.
- Explaining that the large difference observed between EUCLID and LI arises from LI cloud flash detections.
- Suggesting a merged dataset that would benefit from the advantages of both, ground-based and space-borne lightning detection.

8. L250: convention --> convection

Fixed the typo.

9. L308: "...notably exceeded ground-based observations." --> See comment #7. This

paragraph would be a good place to include something about the limitations of MTG-LI compared to ground-based systems.

Added the following sentence (lines 322-324): *“Given that MTG-LI does not provide flash type classification, a combined lightning dataset integrating the benefits of ground-based lightning location systems (e.g. flash type classification) and space-borne observations (e.g. considerably higher sensitivity to cloud lightning) should be considered in the future. “*

Other comments:

O1: It would have been interesting if you had shown also the spatial distribution of thunderstorm days based on LI data. This would have (likely) showed that in some regions a lot of lightning is accumulated only within few days, while e.g. in Africa the high counts are (likely) due to modest lightning over plenty of days. Also, WMO is to my understanding interested on th.days.

This was considered, but we don't have a good method for deriving LI thunderstorm days/hours yet. Definitely a good topic for a future paper.

O2: To me one of the main benefits at least for the met.services under the FOV is that MTG-LI makes it possible to look at the same ~homogeneous data among different institutes.

This is also one of the key messages we are trying to deliver in this article by showing all the nice and smooth lightning patterns that LI has observed across its FOV.