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Atmospheric Measurement Techniques Discussions

Interactive comment on "Concurrent Satellite and ground-based Lightning Observations from the Optical Lightning Imaging Sensor (ISS-LIS), the LF network Meteorage and the SAETTA LMA in the northwestern Mediterranean region" *by* Felix Erdmann et al.

Anonymous Referee #3

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General Comments

This manuscript compares the lightning detection characteristics of the satellite optical sensor (ISS-LIS) with a ground-based network of VLF/LF (electromagnetic) sensors (Meteorage) in preparation for future validation studies of the lightning imager to be onboard the MTG satellite. In order to better understand factors impacting the relative performance of these so-called LLS systems, the authors employed a ground-based

network of VHF sensors (SAETTA) that is capable of virtually 100% flash detection and 3-dimensional mapping of lightning channels within flashes. The authors chose to develop, evaluate, and employ their own algorithm for combining individual low-level reports provided by these LLS systems into lightning flashes, which are then matched in space and time to study the detection characteristics.

This work is a very thorough inter-comparison of these systems, along with a detailed assessment of performance relative to flash characteristics provided by the SAETTA system (flash duration, size, and height profiles). This work provides important information for the scientific community that is working to understand and employ satellite-based lightning observations. Overall, I view this manuscript as being well organized, and technically and scientifically sound. There are some very complicated methodologies and concepts in this work, so reading and understanding the content was sometimes hard work. This is made more difficult by the fact that the primary authors are not native English speakers. I also feel that some of the figures and associated discussions might not be necessary to support the important conclusions. It was difficult to understand the statistical analyses of factors impacting flash detection in Figures 13-17. As a last general comment, the labeling, size, and organization of many of the figure prevent them from readily supporting the findings described by the authors. None of these comments require specific changes by the authors – they are provided as personal opinions from a reviewer that is well-versed in all these systems and would like to see this work appreciated to its fullest potential.

I do have some specific comments, corrections, and recommendations that the authors need to address as they refine and revise this manuscript. This are followed be lesser editorial corrections and suggestions.

Specific Comments

1. Sentence on lines 47-48: networks with "widely-spaced" VLF/LF sensors (like Meteorage and the U.S. NLDN) report far more cloud pulses than return strokes, because

they are sensitive to vertically-oriented current-carrying channels in “larger” IC flashes (see Cummins and Murphy, 2009 or Nag et al., 2015). I would say that they have “. . . somewhat limited total lightning detection efficiency (DE).” Shorter-baseline VLF/LF systems like LINET and portions of the ENTLN (cited in this work) have very high total lightning flash DE.

2. Line 57: This is the first use of the term “relative DE”, and (unfortunately) one of the referenced papers (Bitzer et al, 2016) use this term to mean the ratio of the conditional probabilities (see their equation (2)), but others do not use this definition. SO – you need to say that you use the common definition of relative DE used in many studies, which is the percentage of matched flashes divided by the number of flash in the other (reference) LLS (if that is what you are doing).

3. Line 138: the sentence about “. . .within 330 ms and 5.5 km. . . ” is not really correct. No group associated with these values will be included in the flash – these are normalizing parameters for a Euclidian distance measure (see Mach et al., 2007 – figure 2)

4. Line 162: The Meteorage network only requires two sensors to report a lightning discharge (see Cummins and Murphy, 2009).

5. The description of LMA in lines 169-177 is not quite correct and should be reviewed by co-authors on your associated SAETTA paper. It reports leader development (associated with breakdown processes or fast leader propagation in established channels), serving to produce a spatial map of possible paths for later, high-current processes in the flash. The phrase “Fast CG discharges traveling between the cloud and ground” is not correct – you are probably referring to dart leaders that can occur in pre-established leader channels for earlier CG strokes, as well as in established channels within IC flashes.

6. Lines 211-213: regarding the authors’ discussion of the rationale for using events rather than groups in the flash algorithm: This reviewer (and many others in the refer-

ences cited in this work) firmly believes that reports from mid- to long-range ground-based VLF/LF LLS networks match well with LIS groups. Long vertical channels during periods of high currents provide localized light sources, and most of this light is produced during periods of less than 2 ms. The timing and centroid location of a LIS group are a good match for such sources. Figures 8 and 9 in Bitzer et al. (2016) show the very tight time- and space-correlations for these discharges. However, this does NOT mean that ALL LIS groups are space- and time-correlated with VLF/LF strokes/pulses. The authors’ accompanying rationale related to lightning mapping and comparisons with SAETTA are quite reasonable. I ask that the authors refine/revise the rationale on these lines under the light of these comments.

7. Lines 284-292: regarding flash matching: This text seems to indicate that flashes are matched if any elements in the two LLS meet the time constraint, and if any elements (the same or different that the ones meeting the time constraint) meet the spatial constraint. This seems problematic, when multiple flashes are closely spaced in time and space. I ask that the authors clarify this point, to be sure that the algorithm is described properly.

8. Lines 397-403: The group:pulse distances should not necessarily be greater than the event:pulse distance, because the group locations are interpolated to sub-pixel spatial resolution by the radiance-weighting of the spatial centroid. Also the position differences reported by Bitzer et al. (2016) are much larger than the actual position differences because of +/- 5 km latitude location offsets associated with LIS yaw maneuvers (see Zhang et al., 2019). This issue is fixed in ISS-LIS. You may want to refine your analysis in the light of these issues.

9. Lines 469 and later: the units for the LIS radiance product is not correct, in terms of the spectral density. The units should be nm, not μm. See Zhang et al., 2019, which also shows that the TRMM-LIS minimum radiance is about 3 μJSr-1m-2nm-1, indicating that it has a lower threshold than ISS-LIS!

Editorial Corrections and Suggestions

10. Introduction, first paragraph: it might be helpful for some readers to also know that total lightning flash rate within a storm is associated with storm intensity features such as ice flux and updraft volume and rate (see Deierling and Petersen (2008) and Deierling et al., 2008, among others)

11. Sentence starting on line 41: "SAETTA" and "mapping" have not been introduced yet, and this sentence is probably not required at this point in the paper.

12. Line 50: the term "LIS groups" is used, but there has been no description of the LIS products (provided later in the manuscript). It might be helpful to do this in 2-3 sentences, or point the reader to section 2.1.

13. Line 90: suggest replacing "for GLM" to "as GLM"

14. Line 94: "orbits" should be "orbit", since there is only one orbit

15. Sentence starting on line 105 ("Among the. . .), does not seen to be a complete sentence.

16. Line 112: suggest changing ". . . characteristics in lightning detection. . ." to ". . .lightning detection characteristics. . ."

17. Line 119: suggest changing "our paper" to "this work"

18. Lines 151-152: suggest changing ". . .from the lightning discharge on earth. . ." to be ". . .from the optical source at cloud-top. . ."

19. Line 196: The sentence starting on this line does not make sense to me. Two events in a flash can be much farther apart than 14.3 km. If you are referring to adjacent events then I do not see how they can be 11.9 km apart at nadir. Please clarify.

20. Line 204: suggest changing "group" to "collection", given the LIS definition of group

21. Line 222: Use of the words "initial element" suggests that all the sources must be

within the ds limit of the first source. This can cause spatially propagating flashes to be broken up. This should be clarified.

22. Line 299: change "onl yup" to "only up"

23. Section 3.2: Just a comment: It seems that the distance and timing offset distributions are produced by comparing all LIS events and all Meteorage pulse/strokes, so (for LIS) it mergers any underlying space:time correlations for individual matched pairs with the time-evolution of light that is observed by LIS, due to things like leader propagation and continuing current in long channels.

24. Lines 444-445: a contributing factor could also be related to increasing length of the optical sources due to finite leader and return-stroke velocities.

25. Lines 516-518: does this paragraph belong before the previous paragraph?

26. Line 528: The vertical displacement of LMA sources in the xlma display at large distances from the center of the network have always troubled me, even after speaking to the developer of xlma. It seems that refraction is not being handled, so that distant source heights are not really useable. Additional insights would be nice but are not required.

27. Line 543: suggest changing "It can be constituted that. . ." to "Overall, . . ."

28. The term "average mean radiance" (and similar terms that reflect statistics of statistics) require the reader to think hard to interpret the variables. Possible better wording could be "the mean radiance averaged over all heights" or something like that

29. Line 550: is it "maximum radiance per flash" or "maximum event radiance per flash" ?

30. Line 558: suggest changing "dark" to "darker", since they are not really dark (they can be seen).

31. Line 583: A reference for the 10 kA value would be helpful

32. 591-592: This seems to be an over-statement. The relationship between current, polarity, and height will vary with storm polarity and type, and falls apart for hybrid (IC+CG) flashes.

33. Conclusions section: Present tense should probably not be used, since the findings may not be universally applicable.

34. Line 614: it would improve clarity if you replaced “to an overall equal proportion” with “when considering the complete dataset”

35. Line 621: Zhang et al. (2019) might be a good reference to add here

36. Line 626: suggest replacing “dark” with “darker”

37. Lines 626:640: It might be useful to add that all of these height-related behaviors are likely driven by the range of heights associated with CG flashes vs. IC flashes.

References used in this review

Cummins, K., and M. Murphy (2009), An overview of lightning locating systems: History, techniques, and data uses, with an in-depth look at the US NLDN, IEEE Trans. Electromag. Compat., 51(3), 499–518, doi:10.1109/TEMC.2009.2023450

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