

***Interactive comment on “Lightning characteristics observed by a VLF/LF lightning detection network (LINET) in Brazil, Australia, Africa and Germany” by H. Höller et al.***

**Anonymous Referee #1**

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GENERAL COMMENTS

The paper presents an overview of lightning observations collected with the same lightning detection network in four different regions in the world (Germany, Brazil, Africa and Australia) during different field campaigns. Such documentation, performed with the same lightning instrument, is unique and should definitively be analyzed. I should point out that such work requires dedicated times and significant efforts during both the campaign phase in the field and during the analysis phase. The Authors, especially the first Author, should be acknowledged.

The paper is well organized and contains significant new material. It also opens doors

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for future studies and I believe that the lightning data presented here should be made available to the entire Atmospheric Science community.

I have one major concern: the Authors are using the ratio of the number of IC (Intra-Cloud) LINET events over the total of IC + CG (Cloud-to-Ground) LINET events. This ratio is, I believe, misleading because it does not represent the common IC:(IC+CG) ratio usually used in the literature. LINET observations, I believe, should be combined in flash components and flash components in flashes, in a similar way that VHF lightning mapper records are analyzed or that NLDN-like records are processed to form flashes. I would not ask the Authors to develop such algorithms but they should mention in the paper that i) the LINET-based IC:(IC+CG) ratio is different to the one discussed in the literature and ii) that it is envisaged to combine the LINET events in flashes in the future.

The section dealing with the NO production is interesting. It provides new results on the participation of the different flash components in the NO production even if some assumptions are used such as extending Wang et al.'s relationship to higher/lower current ranges and assuming that the current measured by the lightning sensor is comparable to the one used in the Wang et al.'s relationship.

SPECIFIC COMMENTS

Page 6063, lines 24-26: in that phrase, you are mentioning the “total daily lightning rates”, are those rates deduced from the LINET event rates or from LINET flash rates?

Page 6064, lines 23-25: I agree with your comment.

Page 6067, line 19: I suspect that when you mention ‘horizontal’ you are discussing on LINET capability to provide 2D event location. Am I correct? If so, please add ‘(latitude-longitude)’ just after ‘horizontal’.

Page 6068, lines 1-4: is the term “latter” related to the internal detection threshold? How do you select the proper threshold? Did you perform some preliminary survey on

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the noise level in the different locations you have deployed DLR-Linet? Did all DLR-Linet stations be bset up with the same thresholds?

Page 6068, lines 4-5: when you mention 'typical' do you mean within the inner network? Please precise your statement.

Page 6070, lines 26-27: you are mentioning here the CG/IC ratio. As I wrote above, it is misleading because it does not represent the common CG/IC ratio usually used in the literature. You should state it in your paper. I actually wonder how you would compare LINET data with time-coincident LIS data and deduce for instance a detection efficiency between the two instruments. Would you combine LINET events in flashes and compare LINET flashes to LIS flashes or would you look at finer time scales and compare LINET events to the optical pulses sensed by LIS?

Page 6072, lines 7-14: would it be possible to plot the discrimination area (D) in Figures 5, 11, 18 and 24 as it is done in the other latitude-longitude Figures?

Page 6072, line 22: does it lead always to an overestimation?

Page 6074, line 24: what do you mean by 'main lightning region'?

Page 6075, lines 1-4: what is % of IC events in Figure 7?

Page 6075, lines 6-14: I wonder if you have any way to fix that large errors. Is it due to instrumental noise, high noise level at one or more station sites, or are they intrinsic to the signal emitted by the lightning flashes?

Do you see during any intensification of the convection the vertical distribution of the LINET sources changing in a similar manner as it has been shown with LDAR (eg Ushio et al., JAM, 42, 2003) or LMA observations?

I wonder about your statement on associating high altitude LINET strokes as potential sources of jets or developing channels of bolt-from-the-blue lightning. It is only an assumption for the moment. I do believe comparison with other lightning mapping

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sensors should provide some preliminary answer. For example comparing concurrent LIS observations with LINET deployed at the different locations you operated it would be a first step. I suggest to study LIS Science dataset (where the entire optical pulses are available). I won't be using LIS flash data because your need to look in detail the optical signal and to identify where LINET locates temporally and spatially the flashes relative to the optical radiation.

Page 6076, lines 9-10: did you apply any specific set up to avoid any human-related noise? Or did you keep the same detection configuration during the different field campaigns?

Page 6076, lines 23-27: I am wondering how your lightning measurements are representative relatively to long time series. How confident are you that your measurements are climatologically representative? It is not a criticism I am making here.

Page 6077, lines 16-20: again I having difficulties to gauge your IC-fraction because it does not correspond to what we are used to.

Page 6078, lines 3-5: I had a hard time to understand your phrase the first time I read it. Could you rephrase it and even split in two parts?

Page 6079, lines 4-7: based on which criteria do you determine the intensity of the cells? Do you use LINET event rate, density map of LINET events?

Page 6079, lines 10-11: when you mentioned the terms 'two major events', I guess you are using the LINET event rate to identify these two events. Right? I would mention somewhere in that statement that we are dealing here with multiple storms occurring at the same time.

Page 6079, lines 15-16: Where are located that 14-17-km height bursts? In the inner region of LINET?

Page 6079, line 29: I am surprised by this large vertical error of 6 km. Have you any idea about its origin? What is the % of LINET events having such large vertical error

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for the population of LINET events shown in Figure 13?

Page 6080, lines 7-9: I suggest that you develop in the future some algorithms to combine the LINET events in LINET flashes.

Page 6081, lines 7-8: I suspect that when you mentioned “detection efficiencies” you were thinking about the network having all its stations fully operational. Am I correct?

Page 6082, lines 12-13: what is the impact on your AMMA data collection relative to the other datasets in having added “an additional requirement for getting most reliable classification in the inner station”? Does it mean that the LINET network finally exhibits some differences between the AMMA setup and the other setups?

In Figure 18, in the sector 7N-8.5N & 3E-4E, the lightning flashes seem to be distributed along a line. Is it real or is it due to some noise?

Page 6083, lines 3-5: same question as for Page 6075, lines 6-14: do you see during any intensification of the convection the vertical distribution of the LINET sources changing in a similar manner as it has been shown with LDAR (eg Ushio et al., JAM, 42, 2003) or LMA observations?

Page 6084, lines 12-19: I am wondering if the noise levels are the same between South of Germany and other locations where you deployed your LINET network. In other words, can you confirm that the LINET network used in Germany exhibits a similar setup to the ones used in the other regions?

Page 6085, lines 10-11: I think that the definitions of the parameters listed in that phrase are described earlier in your manuscript. Am I correct?

Page 6085, lines 18-24: I wonder if your preliminary results are consistent with what was found during the EULINOX campaign. I wonder if during the EULINOX there has been some attempts to document IC/CG ratio.

Page 6087, line 2: what is the % of LINET events plotted in Figure 25b having errors

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below 3.5 km?

Page 6087, lines 17-18: on which assumption(s) do you base your statement “Both systems detect the majority of the VLF sources”?

Page 6087, lines 19-23: in Figure 26, the vertical density of LINET events decreases as function of time. Is it due to the properties of the storms or is it due to better accuracy in locating the VLF signal along the vertical, the storms after 1500 UTC being located over the network?

Page 6068, lines 18-19: the notion of flash is more relevant here. I am having some concerns on what really represents the daily LINET strokes. We are coming back here to my major concern on the use of LINET strokes and not LINET flashes. You should remind the Reader that the daily stroke rate does not necessarily represent the daily flash rate. For example CG flashes with multiple ground connections would be counted many times.

Page 6088, lines 22-23: here too, I am having a hard time to really sense what the ratio of strokes from one region to another one can represent because the number of storms is different from one region to the other one, and because the number of strokes per flash can also be different. I think it is misleading.

Page 6089, line 22: please explain what you call -IC and +IC.

Page 6090, lines 6-8: please provide the total number of samples in each category (-CG, +CG; -IC, +IC).

Page 6090, lines 10-16: I want to be sure that I understood correctly the plot in Figure 28, especially the “error” bars. The “error” bar is computed on the daily basis for a given range of current within 1-kA bin. So for every region, for the 4 categories of LINET events (-CG, +CG, -IC, +IC), you have computed the ratio of each LINET event category on the daily basis. Then you computed a standard deviation of that ratio (for the different regions and types of LINET strokes). Am I correct? By the way did you

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compute the ratios on the daily basis, ie from 00 UTC to 24 UTC, or from 00 LT to 24 LT, or from roughly the beginning time of the convection to the beginning time of the convection + 24 hours? You wrote that the mid-latitude statistics exhibits larger variability. It is an interesting result. I initially thought that it was due to statistical sampling issue, but looking at Figures 4, 10, 16 and 23, the number of core cases is the highest in the mid-latitudes. I guess Figure 29 deals with the same population of LINET data but I am curious to see the plot in Figure 29 for the four regions separately and for the different IC and CG categories. Could you please add that additional plots in Figure 29 in addition to the plot already given in Figure 29?

Pages 6090-6091, lines 26-9: I think you need to remind the Reader that you are dealing here with strokes and NOT flashes. Page 6091, lines 16-27: I found interesting that the Australian storms exhibit statically higher peak current for -CG strokes. I wonder about your distribution above 50 kA or below -50 kA. What is the highest current value you have recorded for the different regions and for the different LINET event types (-CG, +CG, -IC, +IC)?

Page 6092, lines 4-11: I don't understand your statement "Consequently, high relative peak stroke frequencies imply a narrow vertical profile as can be noted from Fig. 30". Could you please clarify your statement? What is the impact on the vertical error on that vertical distribution? What is also the impact on the current distribution on that vertical distribution? In other words, are those vertical distributions dependent of the current?

Page 6092, lines 19-23: I TOTALLY agree with you and it comes back to my main concern about not having combine LINET events in LINET flashes. I agree with you when you mention that some IC LINET events can be part of a CG flash. You need also to mention that IC flashes can also exhibit multiple IC LINET events as shown in Figure 2 in Betz et al. (GRL, 2008).

Page 6093, lines 5-16: Could you confirm that the % you are computing is relative

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to the population of LINET events that were retrieved with a vertical location error < 3km and a current > 5 kA? The data you collected and presented encompass different stages of the storm, ie developing, mature and dissipating stages. So I am having some troubles that a single vertical distribution of the charge layers can fit the different stages of the storms. I guess the next paragraph (lines 17-23) should be relocated at the beginning of the current paragraph (lines 5-16). I am also wondering about possible tilted charge regions (as already documented in studies where LMA observations were available).

Page 6093-6094, lines 24-7: I am wondering about to what the LINET VLF sources are associated with. Are those events occurring at the beginning of the flashes as Betz et al. (GRL, 2008) have documented, or are they recorded later during the life of the flashes? I understand quite well that it is not easy answer and more investigations are needed.

Page 6094, lines 16-22: how applicable is Equation (6) to natural lightning flashes?

Page 6095, lines 3-12: please indicate that the vertical "error" bars, associated with the cumulative distribution frequencies, are also cumulative, if I am not mistaking.

Page 6096, lines 1-4: I agree with you but for current below -20 kA. No?

Page 6096, lines 16-17: I don't understand your statement.

Page 6098, lines 16-17: your statement is a bit misleading I believe without some detailed analysis of LINET data in synergy with VHF lightning mappers. One should really consider making comparison of concurrent observations of LINET and VHF mappers in order to determine to what different successive IC LINET sources correspond. It is not yet proved that successive IC LINET sources could be joined to form physically a lightning component on the opposite of what can be done with VHF interferometric or time-of-arrival VHF measurements. I would suggest to reword your phrase.

Page 6098, line 27: I guess you are speaking about current distribution. No?

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Page 6099, line 3: what about the amplitudes above 100 kA??

#### TECHNICAL CORRECTIONS

Page 6081, line 27: please spell out WAM.

Page 6082, line 20: replace "ware" by "were".

Page 6087, line 27: replace "it's" by "its". No?

Table 6: I think the ratio  $Nic/(Nic + Ncg)$  is not given in %. Am I correct?

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