

Interactive comment on “Global Distribution of Winter Lightning: a threat to wind turbines and aircraft” by J. Montanyà et al.

Anonymous Referee #2

Received and published: 17 February 2016

The paper “Global Distribution of Winter Lightning: a threat to wind turbine and aircraft” provides new analysis of global lightning data, focusing on the distribution of winter thunderstorms, that are known to be threat to aviation and wind turbines. The data analysis approach is novel, as provides a useful comparison of the relative intensity of regions of winter thunderstorms. The quality of the analysis and report suggests that it is of a sufficient standard to be published without major corrections; however the number of minor corrections required is significant. A very high proportion of these are due to language issues, where the point made is acceptable, but the wording requires clarification. Additionally, there are also a number of scientific questions that need to be addressed.

- GENERAL COMMENTS

C1

The use of a threshold of 5°C at 900hPa is not sufficiently explained/justified. Why isn't 4°C, or 6°C, appropriate? What is the impact of using different temperature/pressure levels? It may be that this approach has been justified in existing literature, but if this is the case, an appropriate reference would be required.

The use of these specific criteria also means that thunderstorms at high latitudes in the summer are still classified as “winter” thunderstorms. This can be seen in Figure 4, where lightning in the meteorological summer is classified as winter lightning in North America and northern Asia (bottom left subfigure) and near to the Southern Atlantic and Southern Indian Ocean (top right subfigure). The term is appropriate in general, but this characteristic should be discussed, as it may be that these (technically) summer thunderstorms actually exhibit characteristics similar to winter thunderstorms (i.e. in terms of the heights of charged regions).

Although the comparison of the relative intensity of global regions of winter lightning activity is useful, the authors do not provide enough analysis of the global variability in WWLLN detection efficiency (DE). In page 6, line 31, they state that the DE of WWLLN “is considered to be 11%”. There will be significant variations in this globally, however, based on sensor distribution. Further to this, Rudlosky and Shea (2013) showed that WWLLN is apparently three times more likely to detect a flash over the ocean than over land, based on comparison with LIS data. (Rudlosky, Scott D., and Dustin T. Shea. "Evaluating WWLLN performance relative to TRMM/LIS." *Geophysical Research Letters* 40, no. 10 (2013): 2344-2348)

The figures present the results in units of strokes per square kilometer per year. Is there a reason that WWLLN fixes were not merged into flashes using suitable space/time criteria? This would make the data easier to compare with satellite data (OTD, LIS, or the upcoming GLM and MTG-LI) and other analyses of lightning density, which also generally use flashes.

The middle paragraph of the Discussion section (Page 7, lines 12-21) seems a little

C2

muddled. The authors leap from a one-sentence analysis of one area, to another area, to another. The Mediterranean and New Zealand are mentioned before North America and the North Atlantic, despite the latter experiencing much higher winter lightning densities than the former, based on Figure 3. More context in the text, i.e. peak densities or winter thunderstorms days, would make this section simpler to understand without constantly needing to refer to the figures.

The colour scales used in Figures 4 and 5 could be adjusted to allow for the appreciation of greater detail in regions of stroke densities above 0.2 strokes per square kilometer per year. Large regions of North America, North Atlantic and the North Pacific are simply displayed as block red in Figure 3. The current colour scale between 0.0 and 0.2 could be kept the same, so that 0.2 is still red, but values about that could transition into black/grey/purple, for example. See Anderson and Klugmann (2014) as an example.

There are a large number of specific comments and technical corrections that are simply due to the use of language, but do not prohibit understanding of the topics discussed. References were generally accessible and appropriate for the text, unless otherwise stated in the specific comments.

- SPECIFIC COMMENTS

Page 1, line 9: "... for new generation of aircraft." does not read well in English. Suggest "... for modern aircraft."

Page 1, line 10: "That is because the use of lightweight of ..." does not read well in English. Suggest merging with the previous sentence: "... for modern aircraft, due to the use of lightweight composite materials."

Page 1, line 14: "... characterized for producing ..." does not read well in English. Suggest "... characterized by a relatively high proportion of ..."

Page 1, line 14: "... type ..." Should be "... types ..."

C3

Page 1, line 15: "However, up to now ..." The however is unnecessary, and "up to" does not read well. Suggest "Until now ..."

Page 1, line 17: "... three maps ..." Actually, six maps are presented, in three figures.

Page 1, line 21: "... provided here can be used for providing ..." Double use of forms of the word "provide" does not read well. Further, the information presented in the manuscript is not sufficient for an entire assessment of risk on its own. Suggest "... provided here can be used in the development of a ..."

Page 1, line 26: ""But, although ..." Word "But" is not necessary.

Page 1, line 26: "... winter thunderstorms is low ..." It would read better is this were put in context. Suggest "... winter thunderstorms is relatively low compared with summer thunderstorms ..."

Page 2, line 9: "... events to airplanes ..." does not read well in English. Suggest "... events involving airplanes ..." or "... events involving lightning connections to airplanes ..."

Page 2, line 12: "This phenomena present ..." Mixes singular and plural, should read "This phenomena presents ..."

Page 2, line 13: "... under this conditions." Mixes singular and plural, should read "... under these conditions."

Page 2, line 15: "... interactions highlighting the situations related ..." does not read well in English. Suggest "... interactions related ..."

Page 2, line 15: "That is ..." does not read well in English. Suggest "This is ..."

Page 2, line 21: "... can receive both downward and initiate upward ..." The word "both" refers to receiving downward and initiating upward lightning, and so should appear earlier. Suggest "... can both receive downward and initiate upward ..."

C4

Page 2, line 23: “We do that . . .” does not read well in English. Suggest “We do this . . .”

Page 2, line 31: Fig. 1d is referred to in the text before Figs 1b and 1c. It would make sense then to either rearrange this sentence, so Fig. 1d is mentioned after the previous figures, or to rearrange the subfigures in Figure 1 so that what is currently 1d becomes 1b, 1b becomes 1c and 1c becomes 1d.

Page 3, line 1: It has been contested whether IC lightning is technically a “flash” in the same way as CG lightning, as there is not a stepped leader/return stroke structure. I have debated this previously with other scientists, who prefer the term “IC discharge”. The change here is not an absolute necessity, however.

Page 3, line 1: “Upward induced lightning is more likely to occur . . .” It would be useful to clarify whether this refers to absolute numbers of upward induced lightning events or relative numbers. As an arbitrary example, if the relative proportion of events drops by 50%, but the total amount of lightning increases by a factor of 4, the absolute number doubles.

Page 3, line 16: “. . . because of the necessity of . . .” This does not read well in English. Suggest “. . . because the presence of . . .”

Page 3, line 16: “. . . charge region necessary to . . .” This does not read well in English. Suggest “. . . charge region is necessary to . . .”

Page 3, line 29: “. . . turbines belongs to . . .” Mixes singular and plural, should read “. . . turbines belong to . . .”

Page 3, line 30: “. . . raised the interest.” This does not read well in English. Suggest “. . . has been discussed and investigated.”

Page 4, line 1: “. . . an hour especially when . . .” Suggest inserting a comma, i.e. “. . . an hour, especially when . . .”

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Page 4, lines 9-10: “Montanyà et al. (2014) showed a example.” This is not a full sentence. “a” should read “an”. Suggest merging with the previous sentence, i.e. “. . . lightning occurs, as observed by Montanyà et al. . . .”

Page 4, line 15: “. . . with temperatures decreasing with height over a large depth of the troposphere (steep lapse rates)”. The atmosphere can be absolutely stable, even if the temperature decreases with height. This comment is not strictly necessary, so I suggest removing it and allowing the interested reader to check the associated reference for further detail on conditional stability.

Page 4, line 16: “. . . vapor whose latent . . .” Water vapor is not a “who”. Suggest “. . . water vapor from which latent . . .”

Page 4, line 19: “Convergence and ascending air near the surface is . . .” Mixes singular and plural, should read “Convergence and ascending air near the surface are . . .”

Page 4, line 20: “. . . moisture content is much reduced . . .” This is not absolutely always the case, only generally. Suggest “. . . moisture content is generally much reduced . . .”

Page 4, line 20: “Low pressure systems are more vigorous . . .” This is not absolutely always the case, only generally. Suggest “Low pressure systems are generally more vigorous . . .”

Page 4, line 21: “. . . polar and arctic regions southward to mid-latitudes, . . .” This section is talking globally, not only about the northern hemisphere. Suggest “. . . polar regions towards mid-latitudes, . . .”

Page 4, line 23: “. . . then experience no inhibiting warm layers on their way to the equilibrium level . . .” It is possible that warmer layers are encountered, but that are insufficiently warm to remove the buoyancy of the rising air parcel. Suggest “. . . then gain sufficient buoyancy to ascend large vertical distances . . .”

Page 4, lines 23-24: “. . . and occur over large regions over sea . . .” This implies air parcels only occur behind cold fronts. Suggest removing “and occur”.

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Page 4, line 27: "... a relative stagnation ..." It is not clear what this means. Suggest replacing with "... convergence ..."

Page 5, line 2: "... three type of ..." Mixes singular and plural, should read "... three types of ..."

Page 5, line 3-4: "... thunderstorms systems ..." Mixes singular and plural, should read "... thunderstorm systems ..."

Page 5, line 10: "... and the numerous damages to ..." This does not read well in English. Suggest "... and a high rate of occurrence of damage to ..."

Page 6, line 6: "... diverted northward and southward, depending on the hemisphere." It would help to be specific here. Suggest either "... diverted northward (southward) in the northern (southern) hemisphere" or "... diverted poleward".

Page 6, line 9: "This configuration is inherently unstable ..." It would be better to say "This configuration drives the development of atmospheric instability ..."

Page 6, line 16: "... that are useful ..." This has not been conclusively demonstrated yet. Suggest "... that may be of use ..."

Page 6, lines 28-29: "As any long ..." This does not read well in English. Suggest "As with any long ..." Page 6, line 31-32: "... 11% according to ..." Remove the "according to", and the "and" later in this sentence, and enclose the references in parenthesis.

Page 7, line 3: "Probably the most useful metric..." The most useful metric would be data from a high detection efficiency network with well understood weaknesses covering the area of interest for an extended number of years. That way, the true CG flash rate, and thus the true risk, could be estimated to a high precision. Suggest "An improved metric..."

Page 7, line 9: "... we resumed the ..." This does not make sense. Suggest "... we summarized the ..."

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Page 7, line 12: "... more critical to ..." This does not read well in English. Suggest "... more vulnerable to ..."

Page 7, lines 13-14: "The Japan mainland is surrounded by winter thunderstorms..." This sounds like the thunderstorms are permanent. Suggest "Waters around the Japanese mainland are particularly susceptible to winter thunderstorms..."

Page 7, lines 14-15: "... particularly active reaching in some areas about 30 days of winter thunderstorms ..." This does not read well in English. Suggest "... particularly active with some areas experiencing about 30 days of winter thunderstorms ..."

Page 7, lines 16-17: "In the case of North America, the highest number of annual winter thunderstorm days is located in the Atlantic Ocean." North America and the Atlantic Ocean are geographically separate, this sentence is not well phrased.

Page 7, line 17: "Although the central ..." Should include "in", i.e. "Although in the central ..."

Page 7, line 17-18: "... US the number of winter thunderstorms are not so high ..." This does not read well in English. Suggest "... US winter thunderstorms are not as frequent ..."

Page 7, line 22: "... as the first indicator of risk to winter ..." This does not read well in English. Suggest "... as an initial indication of the risk of winter ..."

Page 7, line 25: "That is also important ..." This does not read well in English. Suggest "Lightning risk is also important..."

Page 7, lines 25-27: It is stated in the last sentence of the Discussion that winter thunderstorm activity is "concentrated from October to June", i.e. in 75% of the year. I would view a concentration as generally referring to a minority of a sample.

Page 7, line 30: "... for self-lightning initiation." This does not read well in English. Suggest "... for lightning self-initiation."

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Page 8, line 1: “But Japan is . . .” This does not read well in English. Suggest “Japan is . . .”

Page 8, line 2: “. . . lightning but other . . .” This does not read well in English. Suggest “. . . lightning, as . . .”

Page 8, line 4: “The maps are helpful for risk assessment . . .” This has not been conclusively demonstrated yet. Suggest “The maps may be of use for risk assessment . . .”

Page 8, line 4: “IEC”. Expand this acronym.

Page 8, line 5: “. . . turbines can be submitted to . . .” This does not read well in English. Suggest “. . . turbines can be exposed to . . .”

Page 8, line 6 “. . . for self-lightning initiation.” This does not read well in English. Suggest “. . . for lightning self-initiation.”

Page 8, line 8: “Also high risk locations are those offshore. . .” This does not read well in English. Suggest “Locations at the greatest risk tend to be offshore. . .”

Page 8, line 9: “. . . the new presence of . . .” This does not read well in English. Suggest “. . . the installation of . . .”

Page 8, line 11: “. . . winter lightning will allow to conduct further . . .” This does not read well in English. Suggest “. . . winter lightning may be beneficial in conducting . . .”

Page 8, line 12: “. . . on local lightning data and meteorological data.” This does not read well in English. Suggest “. . . on local combined lightning and meteorological data.”

Page 9, lines 21-23: Montanya et al. (2011) reference not generally available online.

Page 9, line 29: Murooka (1992) reference not accessible unless via web page in Japanese.

Page 10, line 21-22: Wang and Takagi (2011) not generally available online.

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Figure 1: Subfigures 1a and 1b imply that the CG lightning is initiated from the small positively charged region at the base of the cloud. Assuming these figures represent negative CG lightning, it would be better if the branching of the lightning were to extend further into the negatively charged region, and were to spread out within that region (Montanya et al. 2014a, Figure 3 demonstrates the extent of a CG flash within a cloud nicely).

Figure 1, caption: Remove “(Case of Japan)”, this does not make sense.

Figure 1, caption: “Proportions are not meet in the representations.” This does not read well in English. Suggest “Proportions in these diagrams are not to scale.”

Figures 3-5: The font within the figures is slightly too small, and difficult to read. The coastlines and edges of the plots are also very fine. It may be that the figures were created at one size, then had to be scaled down to fit the page. It would be preferable to scale down the original image, so that when it is reproduced in print, the text and edge lines appear less fine.

Figure 4: I have a suspicion that the values of the flash densities in this figure are wrong. If flash densities across North America/Japan are well in excess of 0.2 flashes per square kilometer per year annually, and there are seasons where the values are well below this level, there must be seasons where the flash density is significantly greater than the annual average. Looking at the peak densities in Figure 4, this is not the case. What I suspect has happened is that the number of flashes per grid box have only been divided by the area, to give units of flashes per square kilometer per season. In fact they must then be divided by the number of days in the year and multiplied by the number of days in the season to convert the units to flashes per square kilometer per year. This means that all of the densities are too low by a factor of four.

Figure 4: Subfigure titles contain “900 05”: Presumably these are the temperature height and cut-off settings for the data. These would preferably be removed.

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Figure 4: The details in the maps are hard to see in this plot. There are two options that would improve this situation. One would be to use a single large, narrow colorbar to the right of all four figures, as the same scale is used in each, and the amount of whitespace could also be reduced, to make better use of the available space. Alternatively, the maps could be rotated by 90 degrees to fill a page sideways, which would allow for a lot more detail to be visible.

- TECHNICAL CORRECTIONS

Page 1, line 24: “et al.,2015” should include a space after of comma, i.e. “et al., 2015”.

Page 1, line 24: “Anderson and D. Klugmann” should not include initial, i.e. “Anderson and Klugmann”.

Page 1, line 25: “Poleman” should be spelt “Poelman”.

Page 1, line 29: “(Montanyà et al., 2014)”. There are two Montanyà et al papers in 2014, this reference presumably refers to Montanyà et al., 2014a?

Page 1, line 29: “Honjo, 2014”. Wrong year, should read “Honjo, 2015”.

Page 2, line 10: “. . .Wilkinson et al., (2009) concluded. . .” Comma should be removed.

Page 2, line 10: “. . .Wilkinson et al., (2009) concluded. . .” Incorrect year: should be 2013.

Page 3, line 31: Missing caron and acute from name of author: Radicevic should read “Radičević”.

Page 3, line 33: “Recently Montanyà et al. (2008) . . .” No such reference: suggest Montanyà et al. (2014a).

Page 3, line 34: “Fig. 1 f”. Space between figure number and subfigure letter should be removed.

Page 4, line 4: “Fig. 1b” should refer to “Fig. 1d”.

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Page 4, line 8: “Fig. e and d” should refer to “Fig. 1e and 1f”.

Page 4, lines 9-10: “Montanyà et al. (2014)”. There are two Montanyà et al papers in 2014, this reference presumably refers to Montanyà et al. (2014a)?

Page 4, line 11: “Lightning” misspelled as “Lighnting”.

Page 5, line 16: “mid winter” should be “mid-winter”.

Page 5, line 25: “were” should be “where”.

Page 5, line 27: “artic” should be “Arctic”.

Page 5, line 27: “Holle and Watson, 1992”. Wrong year, should read “Holle and Watson, 1996”.

Page 7, line 1: “Fig. 2 and 3” should be “Fig. 3 and 4”.

Page 7, line 25: Missing closing parenthesis.

Page 8, line 19: Page numbers not needed in Abarca et al. (2010) reference.

Page 8, line 22: Reference requires full title of paper: “A European lightning density analysis using 5 years of ATDnet data”

Page 8, line 23: Incorrect year in Anderson and Klugmann (2013) reference: should be 2014.

Page 8, line 26: Missing “and” between second to last and last author.

Page 8, line 33: Incorrect year in Holle and Watson (1992) reference: should be 1996.

Page 9, line 6: Page numbers not needed in Hutchins et al. (2012) reference.

Page 9, line 25: Missing space in journal title: “Res.Atmos.” should read “Res. Atmos.”

Page 9, line 30: Reference requires full title of paper: “The European lightning location system EUCLID – Part 2: Observations”

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Page 10, line 1: Missing caron and acute from name of author: Radicevic should read "Radičević".

Page 10, line 1: Missing space after colon: "Badea, I:Impact" should be "Badea, I: Impact"

Page 10, line 10: Incorrect page range: "2653-2673" should be "2653-2674".

Page 10, line 29: Missing space and full stop in author's name: "Williams, E.R," should be "Williams, E.R."

Page 10, line 34: Missing indent at start of line.

Figure 2: Caption reads "artic", should read "Antarctic".

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2015-302, 2016.