

Interactive comment on “Lightning flash multiplicity in Eastern Mediterranean thunderstorms” by Y. Yair et al.

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We wish to thank the reviewer for this extensive review and useful comments. The issues raised in this review were all addressed in the revised manuscript.

General Comments This paper aims to conduct a sensitivity study of various temporal and spatial thresholds for grouping strokes into flashes, based on the ILDN data in Israel and the neighboring area. The impetus was to show that because in various regions of the world the properties of thunderstorms and lightning are different, reflecting varying seasonal and meteorological circumstances, applying a unique set of "global" thresholds for multiplicity may be (sometimes) inadequate. For Israel and the Eastern Mediterranean region, thunderstorms mostly occur in winter, and are compact

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and small with low flash rates, and they are very different from summer thunderstorms in the US and Europe which exhibit high flash rates, and certainly from the tropical convective giants of Brazil. Thus, we feel the paper properly discusses why stricter criteria may better represent the multiplicity for small, winter-type thunderstorms. The following text is added to section 2 to better explain our motivation: "Lightning in the Eastern Mediterranean and Israel occurs primarily in winter, and concentrated in the months November-January. Summer months are completely devoid of thunderstorms and any electrical activity. In winter, lightning is most often found in cold-fronts of Cyprus lows which are formed over the warm sea and move eastward toward Israel (Ziv et al., 2009). The clouds that generate lightning are compact cumulonimbus clouds with vertical dimensions of 5-7 km often embedded within a larger matrix of shallower convective precipitation regions. They exhibit intermittent electrical activity with low flash rates and resembles lightning activity over the Sea of Japan (Kitagawa and Michimoto, 1994), which is remarkably different from summer thunderstorms in the US and Europe and the tropical activity in Brazil. Only in few rare storms (1-2 per year), that occur when Red-Sea trough conditions exist (in fall months October-November) does lightning activity resemble that which is found in the tropics.

We did not use any optical cameras to conduct a visual verification of strike distances of different strokes in a single flash, but rather tried to assess the validity of the existing thresholds for thunderstorms in our region. The distributions of inter-stroke distances (Fig. 2a) and intervals (Fig. 2b) show that for over ~95% of the strokes in this sample (7851 strokes), 0.2 seconds and 5 km are sufficiently broad thresholds to properly assign strokes to flashes. The long tails of both distributions may indeed be accommodated by the NLDN thresholds, but constitute only a very small percentage of the data-set. In essence, it is a question of tradeoff between including separate flashes into one event or separating them. We rephrased many of our "recommendations" such that the option is presented and discussed, but without a specific judgment. We also added text that refers to the work by Matsui and Hara (2011) that analyzed lightning data in Japan and conducted a comparison of the NLDN criteria with those used

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by the JLDN. They found that the NLDN criteria tend to slightly overestimate the multiplicity values, because the NLDN groups strokes into flashes in larger area rather than JLDN.

P. 355, lines 9-10: the words "in their view" refers to the authors of the paper by Rakov and Huffins (2003), and we do not take the opposite view, and so the apparent disagreement that the reviewer identifies is just a misunderstanding. We modified the text to make this clearer.

Other Issues 1. We modified the acronym NALDN to NLDN in all relevant places throughout the manuscript. 2. Figure 3 was modified such that only temporal thresholds of 0.2, 0.5, 1, 2 seconds are used. The error in labeling was rectified. 3. As suggested, the precision for multiplicity is kept for two decimal places, but only in places when the value of the second digit is non-zero.

Specific Comments 1. P. 3530, line 3: changed as suggested 2. P. 3530, line 5: NLDN, done 3. P. 3530, line 10: the text was rephrased as suggested 4. P. 3530, line 11, done 5. P. 3530, line 26: the text is modified: "There are several lightning detection networks operating in the US, with varying stroke-to-flash conversion standards. In the NLDN, before its 1994–95 upgrade ..." 6. P. 3531, lines 17-19: the text was changed as suggested 7. P. 3531, line 21: NLDN, done 8. P. 3532, lines 4-5: the part about polarity was removed. 9. P. 3532, line 7: NLDN, done 10. P. 3532, lines 15-19: The suggested text, formula and result were added. Thank you for this very useful suggestion. 11. P. 3532, lines 20-21: the question was merged and the text rephrased as suggested. 12. P. 3534, lines 21-25: the estimation of detection efficiencies of the ILDN were supplied by one of the co-authors (Dr. Y. Katz) from the Israel Electrical Corporation, based on internal company technical reports. We realize that these are not peer-reviewed publications, but rely on them and quote the source as "personal communication". 13. P. 3536, line 2: NLDN, done 14. P. 3536, line 11: done 15. P. 3536, line 14: NLDN, done 16. P. 3536, line 16: We use Ns instead of N, to avoid confusion. 17. P. 3537, line 7: NLDN, done 18. P. 3537, line 12: the text was amended as required. 19. P. 3537,

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line 19: NLDN, done. 20. P. 3537, line 24: NLDN, done. 21. P. 3537, line 25: thank you for pointing this out. . . the area is indeed 100 km² 22. P. 3538, line 3-5: indeed the higher multiplicity above the sea was as a surprise. As the reviewer suggested, we modified the text: "It is somewhat surprising that the multiplicity is higher over the sea, as one would expect the land area to have better and more abundant contact points to the approaching stepped leader (e.g. buildings, trees, power-lines etc.), and hence the likelihood for repeated strokes to the same point should be greater than above the relatively flat sea-surface." 23. P. 3538, line 7: we made the required change. 24. P. 3538, lines 21-22: text was corrected (it was just a typo). 25. P. 3538, lines 23-25: We added the error ellipses for all three high-multiplicity events. The text was modified: "These values fall within 2.5 km indicating a very tight grouping of consecutive strokes in high multiplicity flashes, as shown by the respective error ellipses (Figure 5 e-f). The tight clustering of most of the strokes in all three events suggests that the flashes had more than one ground termination point, but it was still within less than 2.5 km from the main strike point." Indeed, without optical verification we cannot unequivocally deduce that these strokes truly belonged to a single flash with multiple ground termination points, but this is a reasonable explanation. 26. P. 3539, lines 7-8: the numbers all refer to strokes. Text was corrected. 27. P. 3539, line 10: this is now clarified: the coastal region extends 10 km west to the coastline into the sea. 28. P. 3539, line 13: corrected to strokes. 29. P. 3539, line 14: "regular" was changed to "NLDN" as suggested. 30. P. 3539, lines 16, 18, 20: As suggested by the reviewer, we omitted the references to multiplicity using only multiple stroke flashes. 31. P. 3540, line 2: "general" was changed to "NLDN" as suggested. 32. P. 3540, line 20: NLDN, done. 33. Figure 1, caption: the word "winter" was deleted. 34. Figure 3, caption: changed as suggested. 35. Figure 5, caption: corrected as needed. 36. Figure 6, graphs: modified as suggested. 37. Figure 7: The caption now reads: "The distribution of peak current [kA] for single- and multiple-stroke flashes in the October 30th storm." "Single" refers to flashes with one stroke, and the different lines refer to the distribution of peak current as a function of stroke order in events when $m \geq 2$." The legends and heading

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were changed as suggested.

Technical corrections 1. P 3538, line 14: corrected. 2. P. 3538, lines 16-19: text was corrected to correlate with the graphs. 3. P. 3540, line 7: modified. 4. References: the typo was corrected.

Please also note the supplement to this comment:

<http://www.nat-hazards-earth-syst-sci-discuss.net/1/C1912/2013/nhessd-1-C1912-2013-supplement.pdf>

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 1, 3529, 2013.

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