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Comment on wcd-2021-68

Anonymous Referee #1

Referee comment on "Differentiating lightning in winter and summer with characteristics of the wind field and mass field" by Deborah Morgenstern et al., Weather Clim. Dynam. Discuss., https://doi.org/10.5194/wcd-2021-68-RC1, 2021

I thank the authors for their novel empirical investigation of thunderstorm conditions, and for their work to utilize the multi-parameter empirical information to reason about the meteorological dynamics. I think the manuscript is suitable for publication with minor revisions, and will be a helpful practical forecasting aid while supporting clear, physically-based forecast reasoning.

I wanted to comment on the choice of words for the two categories of lightning identified in the study.

“Wind” and “mass/moisture” could be made even more specific and descriptive. The word choice here matters because it conditions how the reader perceives the connection to what actually drives the cloud physics processes that can result in electrification. To this point, the authors note that “wind field” is, specifically, the synoptic-scale thermal wind (line 200), and implies quasi-geostrophic dynamics driving clouds formation. Likewise, mass/moisture is really the specific thermodynamics associated with conditional instability and upright moist convection. These more specific ideas are strongly implied by the authors' reasoning, and so for this reason I encourage the authors to consider adopting more specific terms.

Other comments specific to certain lines of the manuscript are below.

1. If the authors reduce the number of clusters to k=3, do the dark and light, red and blue markers combine more with each other than they do with the yellow markers?

2 Line 36: it is predominantly differential sedimentation rates, not atmospheric motion, that separates the charges after collision. After differential sedimentation, wind shear can act. Also, on line 212 and line 290-1 and line 345: a constant vertical velocity cannot separate charged hydrometeors; the separation has to come from sedimentation within the inertial frame, or by differential motion of particles from one inertial frame to another. A related point is that the cloud life time scale is much larger in winter storms, so even relatively slow vertical motions and charging rates could still result in sufficient charge for lightning.

3. Line 75: in k-means clustering, k is chosen a priori, but the text says it "yielded k=5 clusters," which implies the the algorithm itself determined k and might be confusing to readers. The manuscript later clarifies how this k was chosen (sec. 3.3). I suggest changing "yielding" to "using."

4. Line 110: "on the scenarios without lightning": was the normalization done separately for the summer and winter populations, or aggregated across all no-lightning subsamples? It would also help to describe this process in order as a mathematical formula: first introduce the calculation of the mean and standard deviation of the no-lightning cases, and then state how the other variables were normalized using these quantities. Line 124 and 174 repeats this phrase, and with careful explanation here it can be removed there, unless I misunderstand and normalization is being applied several times.

5. Section 3.3: Were the PCA and the k-means methods applied independently? It seems so. Does independent application of the two methods help give confidence in the interpretation of the results? What were the key principles used to judge high- and low-

meaning clusterings and PCA projections?

6. Line 243 and following: the definition of the cloud used to diagnose the relative cloud temperatures in summer and winter uses only droplets. Concerning the conclusion, "during lightning in winter clouds are – integrated over their depth – overall warmer than summer clouds," how would it change if both ice crystals and droplets were used together to define the cloud? Is there something special about droplets that makes them alone worth considering?

7. Line 310: HSLC storms (because some CAPE is present) typically do release upright convective instability even though they are during the cool season, so I appreciate the authors having introduced the HSNC idea here. It is not the month of the year but conditions associated with the synoptic pattern that control the mechanism by which lightning is generated.