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# *Interactive comment on* "Hybrid variational-ensemble assimilation of lightning observations in a mesoscale model" *by* K. Apodaca et al.

**Anonymous Referee #2**

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It was generally a pleasant read for me on the assimilation of lightening data with the WRF-NMM at a 9-km resolution for a single severe-weather case. The paper is generally well written, and the topic is very interesting. Since this study is the first step to lightning data assimilation, some limitations of the paper, such as a single case study rather than comprehensive statistical comparisons, are understandable. The paper is within the scope of the journal and worth publication in general. However, it is not very straightforward to find the exact impact of assimilating lightning data. I would suggest to improve the overall presentation of results. Also, some important details need to be provided. I would list specific points as below. Once these points are addressed properly, it may be acceptable for publication.



Specific comments:

1. The impact of assimilating lightening data is not clearly presented in the results. For example, Fig. 9 shows analysis increments, but I found almost no increment where the dense lightening data exist. Also, Fig. 11 shows better analysis fit to lightening observations, simply meaning that the system is working properly, but not necessarily meaning the lightening data help improve NWP. I would suggest to provide analysis/forecast fit to other (unused) observations such as surface stations. Overall revisions on the presentation of results, in particular, clearer presentation of the impact due to additional lightening data (i.e., LIGHT vs. NODA) is strongly recommended.

2. Some important details are missing.

   (a) In section 2.3, it is unclear how to relate $w$ to $w_{max}$. $w_{max} = w$? If so, it should be explicitly stated. I guess usually $w_{max} > w$, and we could define $w_{max} = aw$, with the multiplicative factor $a > 1$, possibly being a function of $w$.

   (b) In section 3.3, it is unclear what are the ensemble initial and boundary conditions, what is the localization setting for ensemble-based covariance, what are the hybrid settings such as weight between ensemble-based and static background error covariances. Also, it should be mentioned in this section that no other observations are assimilated.

3. P.934, L.22, I am not convinced if this is really "new information." Sampling errors due to a limited ensemble size are treated as if they were "information." It is unclear if what is shown here is "information" rather than spurious sampling noise.

4. Section 4.2 describes d.o.f. for signal. I understood intuitively that the d.o.f. for signal mean the number of independent pieces of information from a certain

number of observations considered here. If my understanding is correct, it is important to provide how many observations are considered for each d.o.f. value.

5. It may be interesting to discuss about the potential non-Gaussianity of the lightening data. Lien et al. (2013, Tellus A) suggested an approach to deal with observations that have non-Gaussian error PDF, and taking such an approach may improve the use of lightening data.

Minor points:

1. P.919, L.25, “void” sounds too strong. There are observations such as AMVs and aircraft data.
2. P.920, L.2, “emissions” -> “production”?
3. P.924, L.17, what is the unit of c? counts/hour/m/m or such?
4. P.924, L.24, a dot is missing on top of $\sigma$.
5. P.924, L.25, I thought WRF-NMM is a nonhydrostatic model that has prognostic vertical velocity.
6. P.925, L.3, what is the unit of CWM?
7. P.925, L.18, observed lightning rates were considerably larger than the guess possibly because $w_{max} = w$ is assumed?
8. P.927, L.8, “the diagonal elements of the eigenvalues matrix” -> “the eigenvalues”
9. P.929, L.16, “was” -> “were”
10. P.934, L.9, “no other types of observations being assimilated” may be bad for LIGHT if we think about relative impact. With many other observations, lightening observations may not have as distinct impact.



Interactive comment on Nonlin. Processes Geophys. Discuss., 1, 917, 2014.