Response to Reviewer #2

Thank you for your careful and thorough reading of the manuscript and your thoughtful comments and suggestions. We apologize for the delay in revising the manuscript, as we spent a significant amount of time on the manual validation and inspection of the identified derechos. According to all three reviewers' comments and suggestions, we have made several significant improvements in our manuscript, which we want to highlight before the point-by-point response.

Firstly, we have changed the wording of some terms so that they are more distinguishable and accurate, and we have also improved the language of many sentences so that the manuscript is more understandable. A derecho is a windstorm, while an MCS is a convective system. They are different concepts. Therefore, we change "derecho" to "derecho-producing MCS" when we refer to the MCS associated with a derecho, and "derecho feature" has been changed to "derecho." The dataset developed in this study includes tracking of both derechos and corresponding derecho-producing MCSs.

Secondly, we have incorporated a "forward propagating" criterion in our derecho detection algorithm. Our initial understanding of the term "forward propagating" was incomplete, and we failed to recognize its critical role in defining a derecho proposed by Corfidi et al. (2016). After careful consideration and evaluation, we have adopted and modified two criteria from Corfidi et al. (2016) to establish the definition of "forward propagating." One is that the acute angle between the averaged bow echo orientation and the bow echo series' propagation direction is larger than 45°, and the other is that the bow echo series' propagation speed is at least 30% faster than the 500-hPa background wind speed. Implementing the "forward propagating" criterion removes many windstorms externally forced by extratropical cyclones, aligning with the purpose of Corfidi et al. (2016), which intends to define derechos as internally driven windstorms. "Externally forced" and "internally driven" reflect distinct physical formation mechanisms of those windstorms, which is why Corfidi et al. (2016) proposed a physically based derecho definition. With the updated detection algorithm, the derecho number between 2004 and 2021 has been substantially reduced from 556 to 274 (for ISD) and 220 (for SED). In addition, due to the inclusion of the "forward propagating" constraint in our derecho algorithm, we have decided not to change the name of our dataset to "high wind-producing bow echo." We have updated all the results in Section 6 based on the improved dataset.

Thirdly, we have developed another parallel dataset using gust speeds from the Storm Events Database (SED). Now, our derecho dataset consists of two subsets: one based on gust measurements from the global hourly Integrated Surface Database (ISD) and the other based on SED gust speeds. Although there are some discrepancies between the two subsets, their agreement is much larger than their difference (Figures 9-12 in the revised main manuscript; or Figure R1 below). Moreover, both ISD and SED gust speeds have limitations and uncertainties, hence differences between the ISD-based and the SED-based datasets are expected and understandable. In addition, it also indicates that our usage of lower gust speed criteria for ISD measurements is reasonable and does not change the derecho number much. We must emphasize that using lower gust speed criteria for ISD measurements than SED reports does not mean that the ISD-identified derechos are weaker than the SED-identified ones (or even not derechos). This

is a compromise, considering that ISD stations are limited and may miss many damaging gusts, as we highlighted in Lines 460-469 in the revised main manuscript (as below).

"We emphasize that, in Criterion 4, our ISD gust speed criteria are weaker than the SED gust speed criteria as well as those of previous studies (Squitieri et al., 2023; Bentley and Mote, 1998; Johns and Hirt, 1987), which also estimated the gust swath based on SED damaging gusts. As mentioned in Section 2.2.2, most SED gust reports are estimates, while ISD provides gust measurements from weather stations. SED estimates can capture potential damaging gust occurrences over a much larger area, although with large uncertainties. In contrast, due to the limited coverage of observational sites, real-time ISD measurements may miss substantial damaging gust occurrences in nearby regions. Therefore, we lower the gust speed criteria to capture potential derechos when using ISD measurements. It does not mean that the ISD-based derechos are weaker than the SED-based ones or even not derechos, as elaborated in Section 5."

Fourthly, due to the incorporation of "forward propagating" in the detection algorithm and the development of the SED-based derecho dataset, we have updated some sensitivity tests, evaluations, and the comparisons of our datasets with the NOAA SPC data in 2004 and 2005 and previous studies. Please see Section 5 for further details.

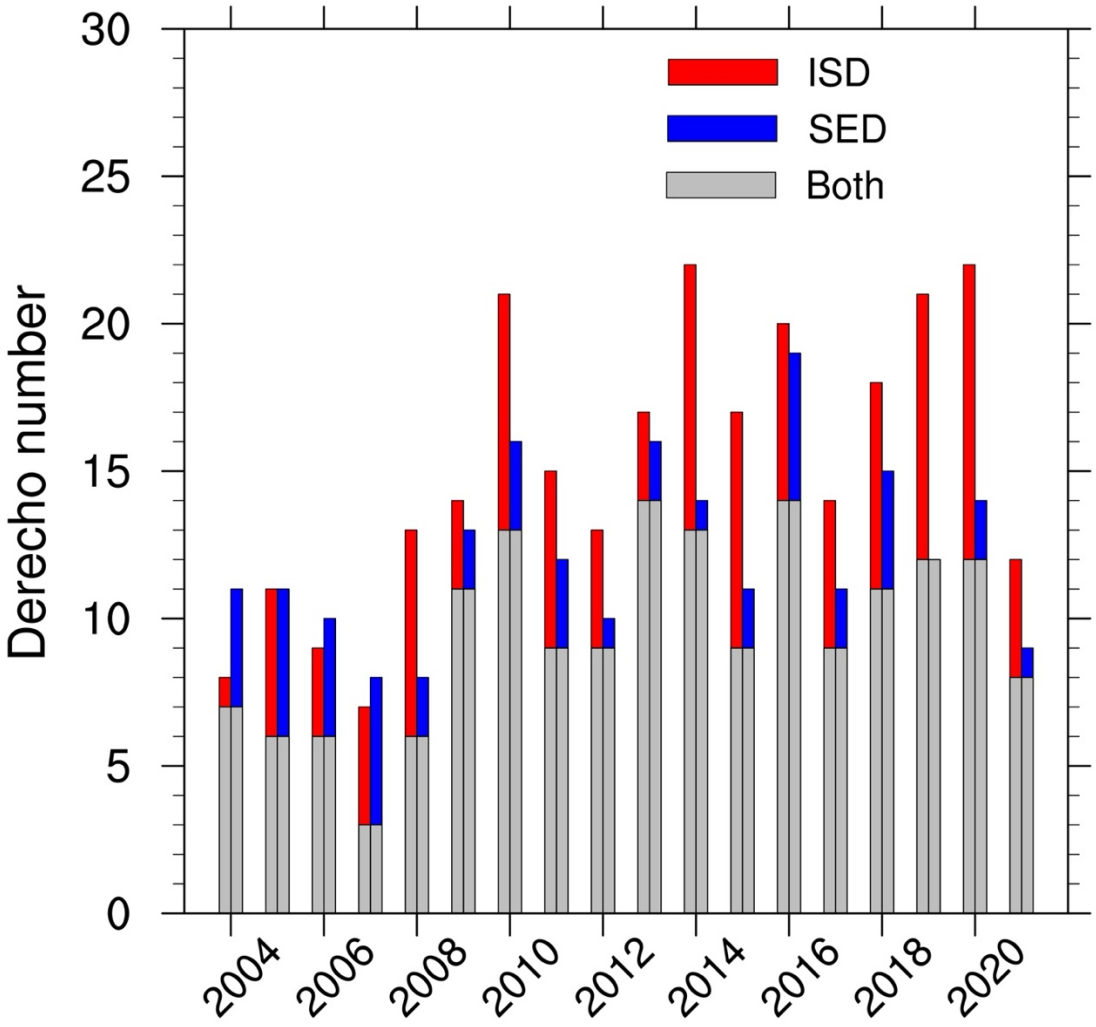

Figure R1. Bar chart of the annual derecho numbers from the ISD-based and the SED-based datasets from 2004 to 2021. Gray shading denotes derechos captured by both datasets, red shading refers to derechos only identified when using ISD gust observations, and blue shading represents SED-only derechos. The figure is the same as Figure 9 in the revised main manuscript.

This article describes the development of a machine learning approach to create a derecho climatology across the United States. The novelty and originality of the work should be praised. The authors for the the most part have a well reasoned approach and methodology to creating this dataset, however there are a few major items of concern that stood out during this review:

I struggle with understanding which definition of a derecho the authors are using and also relying on to classify a feature as a derecho. In the background/introduction the authors present a history on the evolution of the definition of a derecho. I encourage the authors to keep this in the introduction, but I also encourage to authors to present the definition of a derecho they chose for their methodology clearly and provide additional reasoning on why the this specific definition was chose. The authors should really try to use a definition that most closely represents the official definition used by the National Weather Service and/or Storm Prediction

Center. Using a definition that either has a shorter length requirement (or longer one) would impact the number of derechos that are classified in your results.

Reply:

Thank you for your comments and suggestions. As explained above, we change the wording of "derecho features" and hope the manuscript is more understandable now. In the introduction, we highlight that this study aims to develop a derecho dataset following the definition proposed by Corfidi et al. (2016) (Lines 84-90 and 103-107 in the revised main manuscript, or as below). We did not intend to change anything in Corfidi et al.'s definition, but because of the limitations of the wind gust datasets and uncertainties of bow echo identification, we modified some thresholds and introduced the details of how we apply Corfidi et al.'s definition to our available datasets in Section 4. This is a compromise but not a change of definition. Follow your suggestion, we have rewritten Section 4: we first provide a relatively simple derecho definition (as below) and then explain the details separately.

"Considering the inconsistent thresholds used in the above studies and the lack of physical mechanisms in their derecho definitions, Corfidi et al. (2016) proposed a stricter and more physically based derecho definition, which required the existence of sustained bow echoes with mesoscale vortices or rear-inflow jets and a nearly continuous wind damage swath of at least 100 km wide along most of its extent and 650 km long. In addition, the wind damage must occur after the convective system was organized into a cold-pool-driven forward-propagating MCS."

"This study applies a semantic segmentation convolutional neural network (CNN) to detect bow echoes automatically from two-dimensional composite (column-maximum) reflectivity (Z_{Hmax}) data in the United States, which are then combined with an MCS tracking dataset and surface gust speeds to identify derechos using criteria adjusted from Corfidi et al. (2016)."

"Our final criteria are summarized below, with detailed explanations provided afterward.

1) A derecho must be attached to an MCS from the MCS dataset.
2) The derecho must persist for at least 5 hours, with a bow echo present for at least 80% of its lifetime. In addition, gaps between successive bow echo occurrences cannot exceed two hours. All bow echoes must belong to the same bow echo series, as defined in the following section.
3) The derecho bow echo series must exhibit forward propagation, based on two modified criteria from Corfidi et al. (2016):
    - The acute angle between the averaged bow echo orientation and the bow echo series' propagation direction must exceed 45° (Figure 6).

- The propagation speed of the bow echo series must be at least 30% greater than the background mean wind speed at 500 hPa, derived from ERA5 data. The methodology for calculating the averaged bow echo orientation, bow echo series' propagation direction and speed, and the background mean wind speed is detailed in Appendix A.

4) Derecho-associated gust speed criteria vary based on the gust speed source dataset:

- For ISD data: Within 100 km of the derecho-accompanied bow echoes (termed the "derecho area"), there must be at least 10 sites with strong gusts (≥ 17.43 m s^{-1}) and at least 1 site with damaging gusts (≥ 25.93 m s^{-1}).
- For ISD data: At least 10 locations must report damaging gusts.
- The fraction of sites with strong/damaging gusts (ISD) or damaging gusts (SED) must be ≥ 20%.
- Gaps between successive strong (ISD) or damaging (SED) gust reports cannot exceed two hours.
- The gust swath must be at least 650 km in length and 100 km in width. Swath length and width calculations are explained below."

I do not understand the inclusion of surface wind speed observations in this manuscript. Derechos are classified operationally through the Storm Events Database (i.e. local storm reports), not through surface wind observations.

Reply:

Please see above our explanation and clarification.

The organization of introduction needs quite a bit of improvement as well. It was very difficult to follow in terms of readability, partly compounded by the presentation of all the definitions of derechos. The introduction also presents Figure 1 which is a very very busy figure and in its current form, takes away from the paper. I recommend the authors overhaul the section to provide clarity on previous research, the definition of a derecho and motivation for their great ideas as far as developing this database.

Reply:

Thank you for your comments and suggestions. We have simplified Figure 1 and reorganized the sentences for the first derecho definition in Lines 59-71 (as below). Also, as mentioned at the beginning of this document highlighting the key changes in the revision, we have changed the wording of some terms and hope these changes can improve the reading of the manuscript.

'Specifically, they required a derecho to satisfy the following six criteria.

1) There must be a concentrated area of reports with wind damage or convective gusts > 25.7 m s^{-1}, and the major axis length of the area must be at least 400 km.
2) Those wind damage or convective gust reports must show a pattern of chronological progression, either as a singular swath or a series of swaths.
3) The concentrated area must have at least three reports of either F1 damage (32.7-50.3 m s^{-1}) (Fujita, 1971) or convective gust of at least 33.4 m s^{-1} separated by ≥ 64 km.
4) At most 3 hours can elapse between successive reports of wind damage or gust > 25.7 m s^{-1}.
5) The associated convective system must have temporal and spatial continuity in surface pressure and wind fields.
6) If multiple swaths of wind damage or gust reports > 25.7 m s^{-1} exist, they must be from the same MCS event.'

It is difficult to evaluate the results that are presented, especially with the current derecho definition that is used. The current definition that is used (and with sfc wind obs) makes the number of derechos classified by this current form of research difficult to believe. Hopefully an overhaul in the definition used will provide a more realistic number of derechos identified. I do like Figures 9, 10, and 11 in presenting the results. These are great and easy to interpret graphics. I encourage these graphics to stay but adjusted with potential adjustments from the reviews. I would like to see potentially see how the next iteration of these graphics compare to actual confirmed derechos from the same time period.

Reply:

Thank you for your comments. We want to clarify that we follow the derecho definition proposed by Corfidi et al. (2016), which is different from conventional definitions. Since a derecho climatology based on Corfidi et al.'s definition is unavailable, we can only compare our results with prior studies based on conventional definitions. For the details on how we improve the manuscript, please see our response at the very beginning.

References

Corfidi, S. F., Coniglio, M. C., Cohen, A. E., & Mead, C. M. (2016). A proposed revision to the definition of “derecho”. Bulletin of the American Meteorological Society, 97(6), 935-949. https://doi.org/https://doi.org/10.1175/BAMS-D-14-00254.1

Fujita, T. T. (1971). Proposed characterization of tornadoes and hurricanes by area and intensity.