

Responses to Reviewers' Comments for Manuscript egusphere-2026-1174

**Derecho-favoring atmospheric environments
in Finland: characteristics, identification
criteria, and frequency trends**

Addressed Comments for Publication to

Weather and Climate Dynamics

by

Oskari Rantala, Jouni Räisänen, Jenni Rauhala and Marja Bister

Dear Johannes Dahl,

Please find enclosed the revised version of our manuscript entitled “Derecho-favoring atmospheric environments in Finland: characteristics, identification criteria, and frequency trends” with manuscript number egosphere-2026-1174. The changes we have made are based on the reviewers’ minor comments.

Sincerely,

Oskari Rantala, Jouni Räisänen, Jenni Rauhala and Marja Bister

Note: To enhance the legibility of this response letter, all the reviewers’ comments are typeset in coloured boxes. Text which has been added or rephrased in the manuscript is typeset in yellow boxes.

Authors' Response to Reviewer 1

General Comments. The authors have submitted a revised manuscript reviewing conditions favorable for derechos over Finland, and whether such conditions are becoming more frequent with time. The authors have done a satisfactory job in addressing the reviewers concerns. It is especially commendable that the authors pointed out the weaknesses of this study, and were willing to address the uncertainties and caveats with trying to identify an increasing trend in derecho occurrences relative to climate change. Overall, I think this article is ready for publication. I just have a few recommendations below that I think are worth considering.

Response: We are pleased that the reviewer has found our changes to the manuscript satisfactory and thank the reviewer for the recommendations to further improve this manuscript. We have responded to them individually below.

Minor revisions:

Comment 1

Line 26: When you say underestimated the downdraft, do you mean areal coverage or intensity (or both)? Please specify.

Response: We rephrased as follows:

For example, in a study of a severe wind gust event in Australia, El Rafei et al. (2025) showed that column-maximum downdraft velocities were generally about 30 % weaker in the 1-km-resolution simulation than in the 200-m-resolution simulation.

Comment 2

Line 29: Please delete this "for example", since this phrase comes up frequently in this paragraph.

Response: We deleted "for example".

Comment 3

Line 39-40: There are several peer-reviewed journal articles that have recently begun associated the term 'derecho' with internally-forced features that help drive these windstorms. I recommend citing Corfidi et al. (2016), Squitieri et al. (2025), as well as Shourd and Kaplan (2025).

Response: Based on this suggestion, we added a sentence to the paragraph, where we cited the articles. We also changed the order of two sentences to achieve a better flow due to this addition. These changes led to the following:

Derechos also stand out by the formation mechanism of strong surface winds, which is often related to specific features like descending rear-inflow jets and mesovortices in the vicinity of the leading line of convection (Markowski and Richardson, 2010). Indeed, the more recent criteria for a derecho include features suggesting the dominant effect of the cold pool (Squitieri et al., 2025) and evidence of sustained bow echoes, mesoscale vortices, and/or rear-inflow jets (Corfidi et al., 2016; Shourd and Kaplan, 2025). Regardless of the exact criteria, destruction caused by derechos can be comparable to that caused by hurricanes (Ashley and Mote, 2005).

Comment 4

Line 41: This was also found by Johns and Hirt (1987). Please cite here.

Response: We have now also cited Johns and Hirt (1987).

Comment 5

Lines 49-52: This sentence runs too long and is hard to follow. I would like to recommend splitting this sentence, such as: "Derechos occurring in series is a known recurrence in the United States (Ashley et al., 2005, 2007), but is otherwise, to our knowledge, unprecedented in Finland. This unprecedented sequence amid a warming climate naturally poses the question on whether such occurrences could possibly be driven by climate change."

Response: We restructured the paragraph in question according to our response to the 2nd reviewer's Comment 1.

Comment 6

Line 249: Please change "probably" to "likely".

Response: We made this change.

Comment 7

Line 565: Just because there is agreement among trend lines between method choices doesn't mean that the trend is strong. I recommend deleting everything in this sentence after "which".

Response: We deleted everything after "which".

Comment 8

Lines 602-604: Since the Lasher-Trapp et al. (2023) study is a singular study that tried to argue a case for derechos becoming worse due to climate change using the pseudo global warming method, it is only fair to also discuss the other studies that evaluated two other derechos the same way (Li et al., 2023; González-Alemán et al., 2023) and note their varying results, which introduces uncertainty to the derecho severity vs. climate change argument.

Response: We added to the paragraph:

Nevertheless, results from similar studies have been conflicting as, for example, Li et al. (2023) reported that a derecho in North America was weaker in a future environment, whereas González-Alemán et al. (2023) found that anthropogenic warming increased the intensity of a Mediterranean derecho. On the other hand, the results of Kaminski et al. (2025)...

Authors' Response to Reviewer 2

General Comments. The manuscript has improved considerably and the discussion has become more robust with the addition of the teleconnections analysis. A few minor points remain, that I list below. At this point, I recommend minor revisions.

Response: We are pleased that the reviewer finds that the manuscript has been considerably improved. We are also grateful for the minor comments that have helped to improve the manuscript further. We have responded to them in detail below.

Minor revisions:

Comment 1

Literature addition: <https://journals.ametsoc.org/view/journals/bams/105/8/BAMS-D-23-0257.1.xml>; please include this article in the introduction and discussion of the Finnish cases.

Response: We have cited the paper, and due to this addition and based on the 1st reviewer's Comment 5, we restructured the paragraph as follows:

A series of derechos occurring in succession is a well-documented phenomenon in the United States (Ashley et al., 2005, 2007), and a series of four derechos was also documented in Europe between 10 and 12 August 2017, in a belt stretching from northern Italy to Estonia (Surowiecki et al., 2024). In Finland, a country located roughly between latitudes 60° N and 70° N, derechos occurred on four days within a period of ten days in summer 2010. These derechos damaged a total of 8 million m³ of timber (fallen or broken trees) and 35 000 km of power lines (Safety Investigation Authority, Finland, 2010). This unprecedented sequence in Finland raises the question of whether climate change has already affected or may in the future affect both the overall frequency of derechos and the likelihood of multiple derechos occurring in series within the same geographical region. In this study, we investigate historical changes in the frequency of environments favorable for derechos in Finland. The study area is roughly the same where the four derechos occurred in Finland in 2010, but a similar study can also be repeated for other geographical regions.

Comment 2

Introduction Line 26ff: A lot of proxy studies are from when we didn't have these km-scale simulations, and, km-scale simulations don't span the same timeframes as e.g. reanalysis or large ensemble climate simulations. Please rephrase to add a bit of nuance here, especially since km-scale simulations are sufficient to detect Derecho events in general. Please rephrase "some other index"

Response:

Thank you for pointing this out. We have added the following sentence:

Although derechos have been simulated with km-scale simulations (e.g., Li et al., 2023; González-Alemán et al., 2023; Lasher-Trapp et al., 2023), such simulations do not cover time periods comparable to those available from reanalyses or large-ensemble climate simulations.

We also edited the next sentence:

Therefore, proxies, such as convective available potential energy (CAPE), or another index representing instability, and deep-layer shear, have been used to analyze severity of convection in larger datasets with coarser resolution.

Comment 3

Line 28ff: "For example" twice in short succession, please rephrase

Response: We deleted "for example" as mentioned in our response to the 1st reviewer's Comment 2.

Comment 4

Line 61: This deserves a bit more space in the introduction (2–3 sentences), either by highlighting the most relevant teleconnections or by expanding on existing literature.

Response: We added two sentences at the end of the paragraph:

In particular, we determine whether the frequency of favorable derecho environments is correlated with the summer mean North Atlantic Oscillation (NAO), Scandinavian (SCAND), Eastern Atlantic (EA), and Eastern Atlantic / Western Russia (EAWR) indices (Climate Prediction Center, NOAA, 2026), along with the Atlantic Multi-decadal Oscillation (AMO) index (NOAA PSL, 2026). Additionally, we analyze the connection between the frequency of favorable derecho environments and summer mean surface temperature over the study area.

Comment 5

Line 132: Please just define u and v , not their squares

Response: We have now defined just u and v :

The corresponding formula is given in Eq. 1, where u and v are the zonal and meridional wind vector components at all the interpolated altitude levels within the 6–10 km layer.

Comment 6

Equation 1: Mathematically, the mean should be expressed as a bar on top of u and v , rather than the word itself: $\bar{u}$

Response: We have now expressed the equation with bars, rather than words:

$$6\text{--}10 \text{ km } U = \sqrt{\bar{u}^2 + \bar{v}^2} \quad (1)$$

Comment 7

Line 144: From this it is still not clear why 3-hourly data was used. A brief justification would be nice, e.g. stating that this provides sufficient sampling of the convectively relevant hours.

Response: We have added the following sentence:

These selected times provide sufficient sampling for the convectively relevant hours.

Comment 8

Section 4.2: This section has become much clearer, but it would be helpful to have a brief summarizing sentence in the beginning, how parameters were optimized: the adaptation of parameter thresholds was done by selecting values that are marginally exceeded in the observed cases and that minimize the number of DEF-positive days otherwise.

Response: We have included the suggested sentence at the end of the first paragraph of Section 4.2.

Comment 9

Section 6: Given the long discussion of EAWR, a definition of what this weather situation looks like would be helpful at this point.

Response: To describe what the negative EAWR pattern looks like in Sect. 6, we moved these sentences from Section 7 (Discussion) to Section 6, before the final OLS equation:

Additionally, a negative EAWR index in the summer implies a weak negative geopotential anomaly over Denmark and a stronger positive geopotential height anomaly over northwestern Russia. This pattern resembles what we observed in Sect. 3.1 for the synoptic-scale pattern in Finland during derechos.

Thus, to preserve the structure of the EAWR paragraph in Sect. 8, we edited the 7th paragraph in Sect. 7:

As mentioned in Sect. 6, the negative phase of the EAWR index agrees with the synoptic-scale pattern described in Sect. 3.1. This observation is consistent with the relation between negative summer mean EAWR values and a higher frequency of derecho-favoring environments.

Comment 10

Line 607: please rephrase "Many more studies, similar to Kaminski et al. (2025) but applying different methodologies, would be needed before a convincing link between"

Response: We combined the sentence with the previous sentence and rephrased as follows:

Yet, the frequency and intensity of derechos in the future remain uncertain, and hence more studies would be needed before a convincing link between worsening derechos and climate change could be established.

Comment 11

Line 651: please rephrase "justifies asking" and "(and potentially elsewhere...)"

Response: We have rephrased to (en ole varma, onko tämä, mitä arvioija hakee):

Nevertheless, despite the caveats noted in Sect. 7, increasing trend in the number of favorable days with greater 850 hPa θ_e , amid favorable shear in warm-season troughing patterns, raises the question of whether such conditions may make derechos more frequent in Finland, and potentially elsewhere in northern Europe, in a warming climate.

References

- Ashley, W. S. and Mote, T. L. (2005). Derecho hazards in the united states. *Bulletin of the American Meteorological Society*, 86(11):1577 – 1592.
- Ashley, W. S., Mote, T. L., and Bentley, M. L. (2005). On the episodic nature of derecho-producing convective systems in the united states. *Faculty Articles, Papers, and Other Scholarship*, (888).
- Ashley, W. S., Mote, T. L., and Bentley, M. L. (2007). The extensive episode of derecho-producing convective systems in the united states during may and june 1998: A

- multi-scale analysis and review. *Meteorological Applications: A journal of forecasting, practical applications, training techniques and modelling*, 14(3):227–244.
- Climate Prediction Center, NOAA (2026). Teleconnection indices dataset. Accessed 12 June 2026.
- Corfidi, S. F., Coniglio, M. C., Cohen, A. E., and Mead, C. M. (2016). A proposed revision to the definition of “derecho”. *Bulletin of the American Meteorological Society*, 97(6):935–949.
- El Rafei, M., Isaza, A., Sherwood, S. C., Evans, J., Brown, A., Ji, F., and Dowdy, A. (2025). Downdrafts and convective gusts in high-resolution simulations: An australian case study. *Journal of Geophysical Research: Atmospheres*, 130(24):e2025JD044151.
- González-Alemán, J. J., Insua-Costa, D., Bazile, E., González-Herrero, S., Marcello Miglietta, M., Groenemeijer, P., and Donat, M. G. (2023). Anthropogenic warming had a crucial role in triggering the historic and destructive mediterranean derecho in summer 2022. *Bulletin of the American Meteorological Society*, 104(8):E1526–E1532.
- Johns, R. H. and Hirt, W. D. (1987). Derechos: Widespread convectively induced windstorms. *Weather and Forecasting*, 2(1):32–49.
- Kaminski, K., Ashley, W. S., Haberlie, A. M., and Gensini, V. A. (2025). Future derecho potential in the united states. *Journal of Climate*, 38(1):3–26.
- Lasher-Trapp, S., Orendorf, S. A., and Trapp, R. J. (2023). Investigating a derecho in a future warmer climate. *Bulletin of the American Meteorological Society*, 104(10):E1831–E1852.
- Li, J., Qian, Y., Leung, L. R., Chen, X., Yang, Z., and Feng, Z. (2023). Potential weakening of the june 2012 north american derecho under future warming conditions. *Journal of Geophysical Research: Atmospheres*, 128(2):e2022JD037494.
- Markowski, P. and Richardson, Y. (2010). *Mesoscale meteorology in midlatitudes*. John Wiley & Sons.
- NOAA PSL (2026). Amo (atlantic multidecadal oscillation) index time series. Accessed 12 June 2026.

- Safety Investigation Authority, Finland (2010). The storms of july-august 2010. *Investigation report S2/2010Y*.
- Shourd, K. N. and Kaplan, M. L. (2025). A climatology of 1995–2024 united states warm season derecho events and analysis of potential climate forcing associations. *E-Journal of Severe Storms Meteorology*, 20(2).
- Squitieri, B. J., Wade, A. R., and Jirak, I. L. (2025). On a modified definition of a derecho. part i: Construction of the definition and quantitative criteria for identifying future derechos over the contiguous united states. *Bulletin of the American Meteorological Society*, 106(1):E84–E110.
- Surowiecki, A., Pilguy, N., Taszarek, M., Piasecki, K., Púčik, T., and Brooks, H. E. (2024). Quasi-linear convective systems and derechos across europe: climatology, accompanying hazards, and societal impacts. *Bulletin of the American Meteorological Society*, 105(8):E1619–E1643.