Shepherd T.J., Letson F., Barthelmie R.J. and Pryor S.C. How well are hazards associated with derechos reproduced in regional climate simulations? *Natural Hazards and Earth System Sciences Discussions (*nhess-2021-373)

Author's response to reviewer #1 and reviewer #2:

Response to reviewer 1:

We thank the reviewer for their thoughtful and thought-provoking comments. Below we provide a complete list of their comments (in black) and our responses (in green). We further note in brief how this material will be included in the manuscript once we have received all reviews (**for changes to the original text, we provide in this reply, the line numbers in bold referencing the revised (tracked changes) manuscript**).

Review of "How well are hazards associated with derechos reproduced in regional climate simulations?" by Shepherd et al.
This is a model evaluation study to evaluate WRF simulations downscaling to 1.3 km grid spacing with changes of cloud microphysics schemes, lateral boundary conditions (LBC), start date, and nudging. The focus is derecho induced from a mesoscale convective system (MCS). Since derechos cause significant infrastructure damages and economic loss, it is interesting to see if models can capture such extreme events and how the simulations are sensitive to different model setups and physical parameterizations. So, I advocate such studies. However, after looking at the results, I had to doubt whether the simulations were carried out correctly or the simulations were produced from a stable supercomputer/cluster. The model results swift from a convective system simulated with one microphysics scheme to the disappearance of the system with another microphysics scheme is something I never experienced as a senior cloud modeler. Particularly, switching graupel to hail in Morrison scheme also caused the disappearance of the MCS, which is not likely to occur since the change from graupel to hail renders minor changes relative to the entire scheme (mainly in fall speed and density). The hail option is recommended to use for continental deep convective cloud cases by the model developer but it does not simulate the MCS at all. I tested both options in several studies before and this never happened (the simulated convective cloud systems were generally very similar in morphology). In addition, there are so many literature studies with different microphysics schemes for a variety of cases that do not show such a result. As the authors stated this is expected result.
Also, none of the simulations can simulate both derecho and front stages of the observed system, then if the study have focused on why the simulations fail like this, it would still be useful. Furthermore, the sensitivity to two lateral boundary data (ERA5 and ERA-Interim) is also opposite compared with the previous studies (many literature studies showed ERA5 data is improved on ERA-Interim). With all these considered, it is very difficult for me to trust these model simulations thus I would recommend the rejection of the manuscript at this time.
Below I have some specific comments including the appropriate way to calculate the maximum hail size to compare with observations. Hope these comments will be useful for authors to improve the study.

Response: We concur that this is a very challenging event to simulate. We note it has subsequently been shown by Fierro (2014) that assimilation of lightning and RADAR data does improve the fidelity in very short term forecasts (< 6 hr lead time) as depicted visually in that work but without objective skill metrics applied. We further note this was a highly intense derecho. As Shourd and Kaplan (2021) report; "The 29–30 June 2012 "super" derecho was, up until the 10 August 2020 "Iowa Derecho", the most prolific derecho of modern times." Thus, it may present a particular challenge to models, and we believe that while there are parameter sensitivity studies in the literature, this event is worthy of special consideration. Our goal is to present an objective assessment of the inherent model skill as a function of configuration without nudging/data assimilation.

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Author's response to reviewer #1 and reviewer #2:

To illustrate the difficulty with simulation of this event we anticipate adding the following text at/close to line 78 in the original submission **(lines 97 – 107 in the revised manuscript)**:

> A Service Assessment Team from the National Weather Service (NWS) evaluated performance during this event and found that "Unlike many major tornado outbreaks in the recent past, this event was not forecast well in advance." (NOAA, 2013). In part due to the multi-scale forcing of warm-season derechos, this, like other (weaker) derechos proved difficult to forecast > 12-24 hours ahead, and operational models including the North American Mesoscale (NAM) and Global Forecast System (GFS), provided "little assistance in forecasting this event more than 24 hours ahead of time". The day-3 and day-2 convective outlooks valid for 29 June showed only a 5% probability of severe thunderstorms anywhere over the eastern US, and even the Storm Prediction Center 1-day ahead convective outlook indicated only a 15% probability over most of the region that was impacted by the Derecho (NOAA, 2013). During the morning of June 29, some high-resolution, convection-permitting simulations with the High-Resolution Rapid Refresh model indicated the potential for development of intense thunderstorms and only in the afternoon of June 29 was the potential for tracking into the Mid-Atlantic coast identified (NOAA, 2013).

We appreciate the reviewer's concern about the simulations. However, we have reviewed our simulation settings and do not believe our simulations are in error. We have attached all namelist files to this response to review (and will include them all in the Supplementary Materials) and invite any comments and suggestions regarding the model configuration. With regard to the stability of the supercomputer/cluster, all simulations were performed on the Cornell University Center for Advanced Computing Aristotle Red Cloud system (https://federatedcloud.org/index.php). Each Red Cloud instance is a virtual machine in the cloud that consists of a user-defined number of cores. For all of our simulations we have used the same single instance with 28 identical cores (e.g. CPU type with identical clock speed etc.). Furthermore, we have used Docker to maintain version control. WRF was compiled inside Docker. As part of our due diligence procedure, we have undertaken rigorous testing and evaluation of possible machine sensitivity on Red Cloud. This testing included repeating simulations on the same instance, porting the Docker container WRF compile to a second instance and repeating the simulation, and repeating the simulation using different CPUs to test for machine sensitivity. In all cases the simulations we tested showed reproducibility. In the manuscript, we acknowledged the limitations of the study and provided a discussion based on the possibility of different convective forecast realizations. In response to the reviewer's comments and thus have additionally run new simulations with both Morrison settings on another compute platform (NERSC Cori). The additional Morrison simulations are simulated with an Intel compile of the same version of WRF. Below we show results from those simulations relative to original simulations on the Red Cloud system (with GNU compiler). As the reviewer will be aware, even in the absence of any 'system-errors', WRF exhibits a dependence on system architectures and the compiler (see; Hacker et al. 2017; Li et al. 2016; and Lighezzolo et al. 2018). Thus, we do not have an a priori expectation of exact bit-wise reproducibility. However, we do see a relatively high degree of agreement which leads us to have even higher confidence in our simulations. Further, critically for the reviewers point regarding the Morrison hail flag, the same sign of impact of turning on/off this flag is noted in both sets of paired simulations.

Specifically, in the figures below we show results from these simulations in a manner identical to Figures 3-5 in the original manuscript. These additional figures show how the Cori simulations compare to the original Morrison simulations run on the Aristotle platform with GNU. Considering differences in both the compiler and compute system, we show that the differences between the compile and compute

Author's response to reviewer #1 and reviewer #2:

platform are minimal. In addition, the behavior of the hail flag is consistent across the two simulations (i.e. Morrison+Hail vs. Morrison-intel+Hail). Figures 3, 4, and 5 in the original manuscript will remain as is in the revised manuscript, but these updated Morrison comparisons will be added to the revised text with two additional figures showing these results **(Figure 13 inserted at line 1068 in the revised manuscript; Figure 14 inserted at line 1078 in the revised manuscript).**

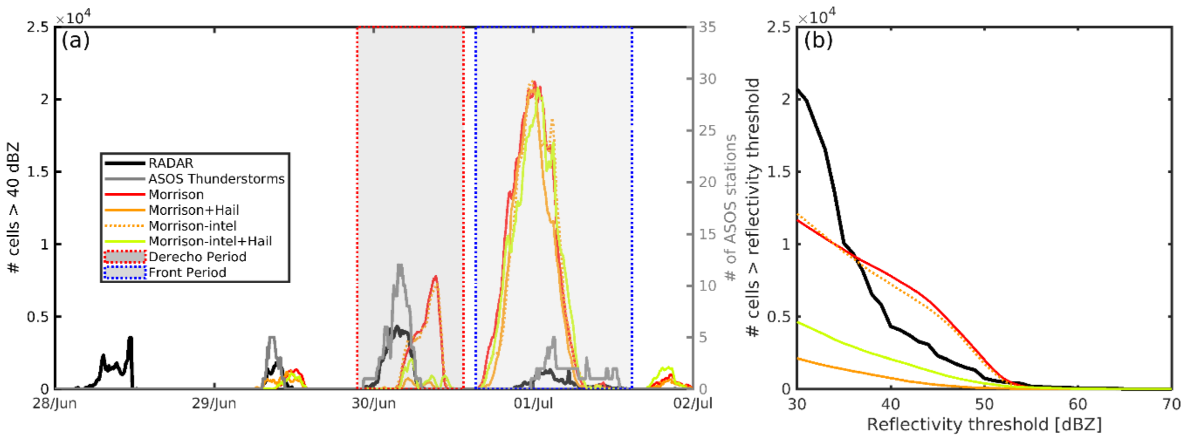

Fig 13 [**inserted as Figure 13 in the revised manuscript at line 1068**]: (a) Time series of number of grid cells in domain d03 with composite reflectivity (cREF) > 40 dBZ from RADAR and the Morrison WRF ensemble members (original Morrison simulations vs. the NERSC Cori Intel compile Morrison simulations). The number of the 34 ASOS stations in domain d03 reporting thunderstorms is shown in grey (right axis). The timing of the (Derecho period: 29-Jun-2012 21:30:00 to 30-Jun-2012 13:30:00) and the frontal passage (Front period: 30-Jun-2012 15:20:00 to 01-Jul-2012 14:50:00) are denoted by the grey backgrounds. (b) The number of grid cells in domain d03 where output from each Morrison WRF ensemble member or the RADARs exceeded the specified threshold during the time step within the derecho period when the maximum number of grid cells exceeded the threshold. For example, in the RADAR observations there is a single 10-minute period during which approximately 5000 grid cells exhibit a value above 40 dBZ.

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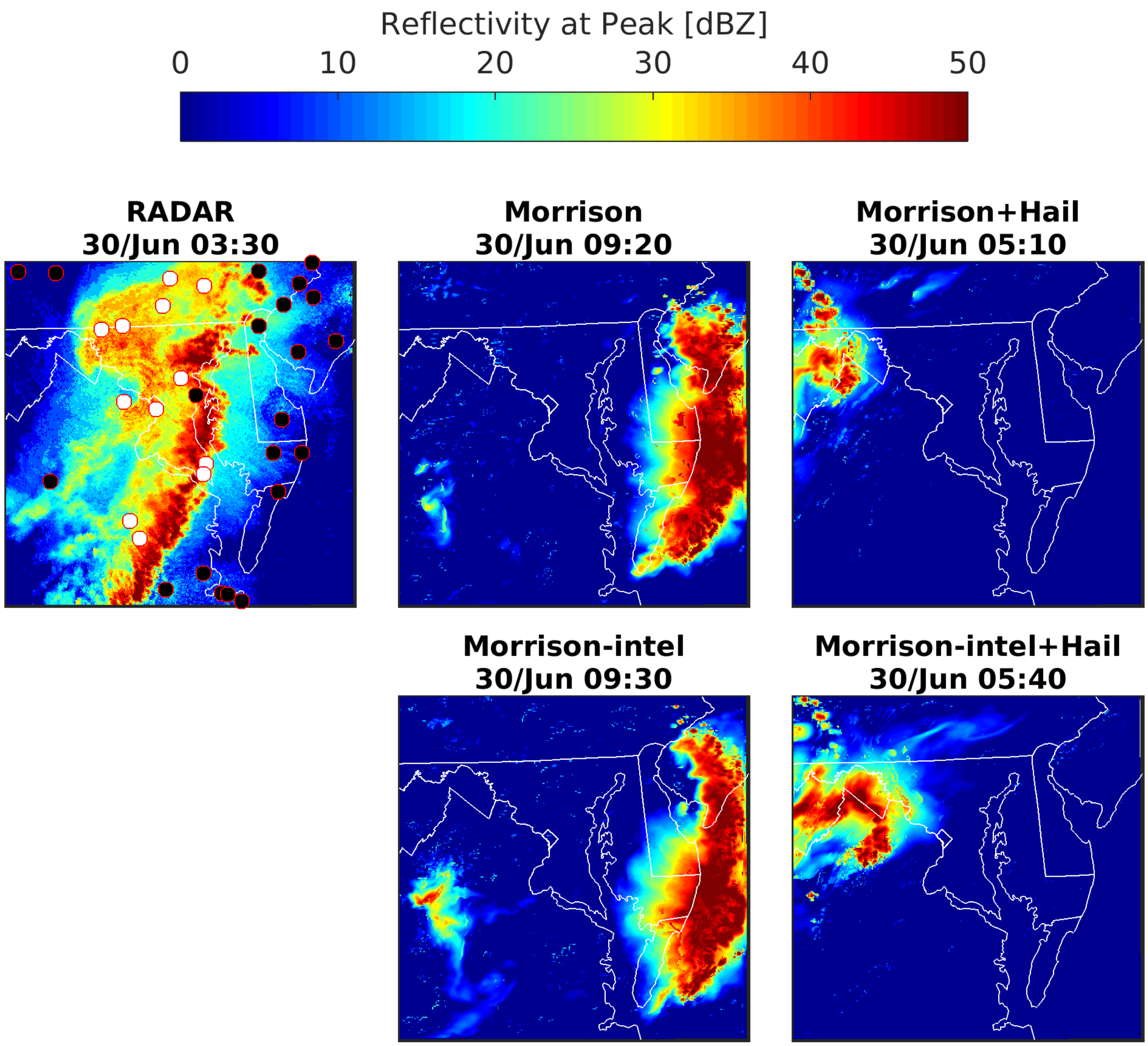

Fig 14 [**inserted as Figure 14 in the revised manuscript at line 1078**]: Composite reflectivity (cREF) in domain d03 at t_p (the time when values from the maximum number of grid cells exceeded 40 dBZ) during the Derecho period from RADAR and each Morrison WRF ensemble member [original Morrison simulations vs. NERSC Cori Intel compile Morrison simulations] (times are noted in panel titles). The RADAR panel includes markers showing the presence (white) and absence (black) of thunderstorm reports from ASOS stations in domain d03 in the hour surrounding 03:30 UTC 30 June 2012.

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Author's response to reviewer #1 and reviewer #2:

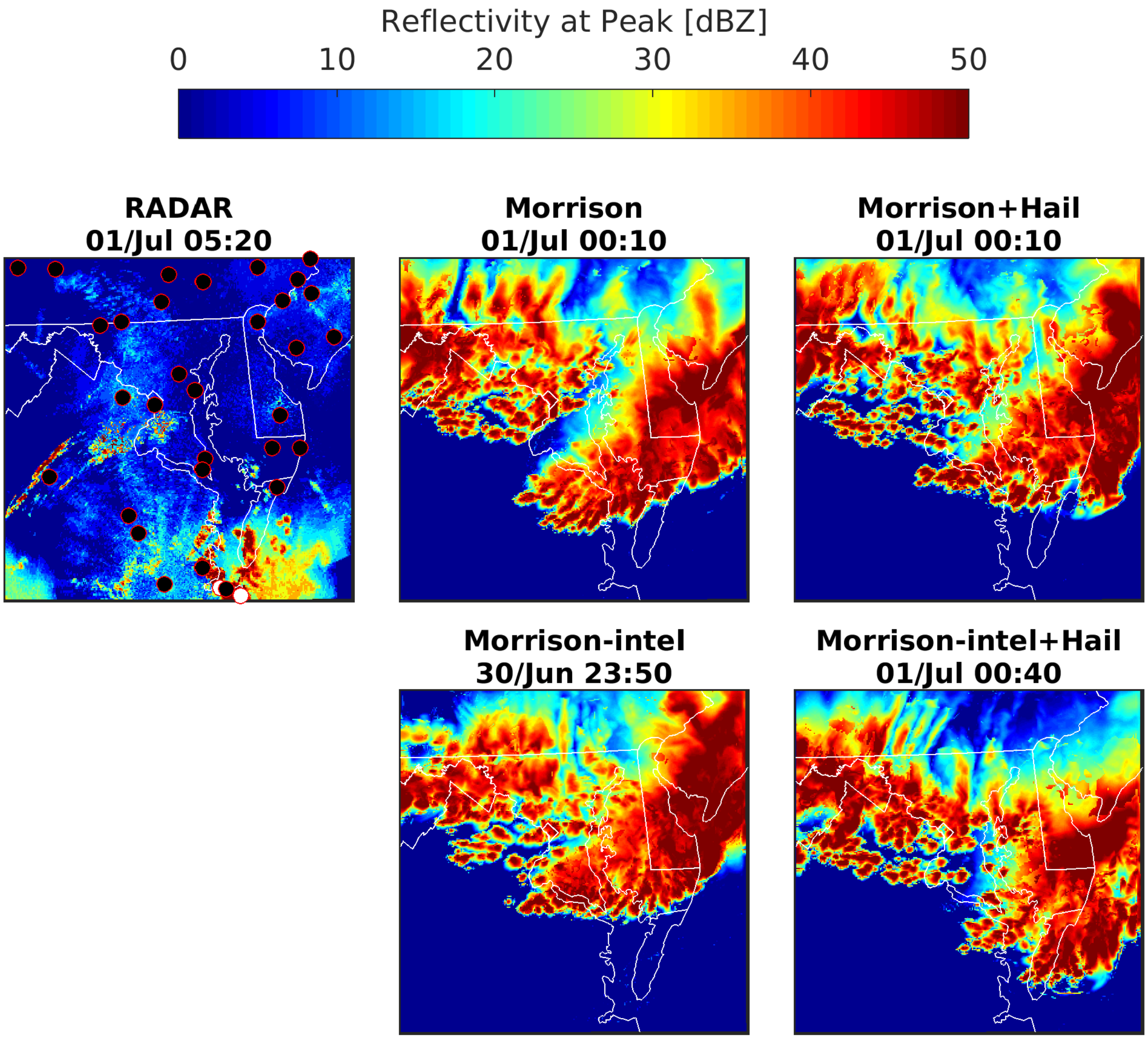

Fig [this additional figure is not included in the revised manuscript or supplemental materials]: Composite reflectivity (cREF) in domain d03 at t_p (the time when values from the maximum number of grid cells exceeded 40 dBZ) during the Front period from RADAR and each Morrison WRF ensemble member [original Morrison simulations vs. NERSC Cori Intel compile Morrison simulations] (times are noted in panel titles). The RADAR panel includes markers showing the presence (white) and absence (black) of thunderstorm reports from ASOS stations in domain d03 in the hour surrounding 05:20 UTC 1 July 2012.

We agree with the reviewer that the results in this paper when using the Morrison scheme with/without the hail switch is indeed interesting. We believe this makes the results even more relevant for the modeling community. We had earlier contacted Hugh Morrison to discuss our findings. His personal communication reads:

"I'm not surprised there are large differences setting the hail flag to "on". Interestingly it looks like results with this are closer overall to Thompson and NSSL. In general setting the flag to hail leads to a

Author's response to reviewer #1 and reviewer #2:

reduced area of reflectivity but sharper precip rates in simulated squall lines (e.g. Morrison et al. 2015, JAS). .... But in "real case" simulations with realistic lateral boundary conditions, initial conditions and a longer forecast time the simulations can diverge much more. We see this every year, for example, at NSSL's spring harzardous weather testbed where, among other things, they analyze WRF ensembles with different microphysics schemes. Anecdotally, we often see large changes in convective structure, timing, placement, and mode using different schemes, especially after ~18-24 hours forecast time. To put sensitivity to microphysical changes into context for such real case runs, we've used ensembles forced with different sets of initial/lateral boundary conditions (say, from GEFS) and ensembles with small perturbations to the initial potential temperature field (Stanford et al. 2019, JAMES)."

We envisage including the precis of the new analyses and simulations at/close to line 419 of the original text (**inserted at lines 502 – 512 of the revised manuscript**) along with the following text:

> The relatively poor simulation performance for each of the ensemble members is consistent with the aforementioned literature regarding the specific challenge that this event presented. However, it also raised concerns regarding a possible issue with the stability of the computational platform. Thus, simulations of two of the ensemble members were repeated on a separate computational platform (the U.S. Department of Energy NERSC Cori Cray XC40) and with a different compiler (INTEL). Bit-wise reproducibility is not expected due to previously documented system architecture and compiler dependence of WRF simulations (Hacker et al. 2017; Li et al. 2016). Thus, these simulations are designed to evaluate whether use of a different system yields marked improvements in terms of the fidelity with which the Derecho is simulated and to evaluate if the response to turning on the hail flag in the Morrison scheme is consistent. The results of these additional simulations are summarized in Figure 13 in terms of the time series of the number of grid cells with high cREF and in Figure 14 in terms of the cREF spatial patterns at t_p. These and other diagnostics (not shown) indicate a high degree of similarity between the output of these simulations and the original ensemble members. Our inference is that the original ensemble members are reliable.

With respect to the importance of the LBC – while ERA5 is generally thought to be superior (and indeed this was our expectation) it is not uniformly the case. Indeed, the question of LBC remains an active area of research (e.g. Ahrens and Leps, 2021). In this specific case the improved performance in simulations with ERA-Interim may be linked to the specific multi-scale dynamics associated with this derecho (see details from Shourd and Kaplan, 2021) that were better depicted in the Era-Interim reanalysis. We have undertaken additional analyses of these IC from ERA5 and ERA-Interim as described in detail below.

The fact that our simulation results are not entirely congruent with the reviewer's (or our) expectations is entirely why we performed these analyses and submitted this manuscript.

Abstract,
"We also examine the degree to which each ensemble member differs with respect to key mesoscale drivers of convective systems (e.g. convective available potential energy and vertical wind shear) and critical manifestations of deep convection; e.g. vertical velocities, cold pool generation, and how those properties relate to correct characterization of the associated atmospheric hazards (wind gusts and hail)."
-The sentence is near the end of the abstract about it is still about the scientific approach. Suggest changing to phrasing it from the angle of describing your key findings, which is more appropriate for a scientific paper.

Shepherd T.J., Letson F., Barthelmie R.J. and Pryor S.C. How well are hazards associated with derechos reproduced in regional climate simulations? *Natural Hazards and Earth System Sciences Discussions (*nhess-2021-373)

Author's response to reviewer #1 and reviewer #2:

We regret the reviewer did not find our abstract sufficiently detailed. We note the instructions to authors with respect to the abstract read; '**Abstract**: the abstract should be intelligible to the general reader without reference to the text. After a brief introduction of the topic, the summary recapitulates the key points of the article and mentions possible directions for prospective research. Reference citations should not be included in this section, unless urgently required, and abbreviations should not be included without explanations. An abstract should be short, clear, concise, and written in English with correct spelling and good sentence structure.' We felt we were generally compliant with that instruction but based on the reviewers comment propose to modify the abstract to read (**inserted at lines 8 – 29 of the revised manuscript**):

> An 11-member ensemble of convection-permitting regional simulations of the fast-moving and destructive derecho of June 29 – 30, 2012 that impacted the northeastern urban corridor of the US is presented. This event generated 1100 reports of damaging winds, significant wind gusts over an extensive area of up to 500,000 km^2, caused several fatalities and resulted in widespread loss of electrical power. Extreme events such as this are increasingly being used within pseudo-global warming experiments that seek to examine the sensitivity of historical, societally-important events to global climate non-stationarity and how they may evolve as a result of changing thermodynamic and dynamic context. As such it is important to examine the fidelity with which such events are described in hindcast experiments. The regional simulations presented herein are performed using the Weather Research and Forecasting (WRF) model. The resulting ensemble is used to explore simulation fidelity relative to observations for wind gust magnitudes, spatial scales of convection (as manifest in high composite reflectivity, cREF), and both rainfall and hail production as a function of model configuration (microphysics parameterization, lateral boundary conditions (LBC), start date, and use of nudging). We also examine the degree to which each ensemble member differs with respect to key mesoscale drivers of convective systems (e.g., convective available potential energy and vertical wind shear) and critical manifestations of deep convection, e.g. vertical velocities, cold pool generation, and how those properties relate to correct characterization of the associated atmospheric hazards (wind gusts and hail). Use of a double-moment, 7-class scheme with number concentrations for all species (including hail and graupel) results in the greatest fidelity of model simulated wind gusts and convective structure against the observations of this event. However, all ensemble members fail to capture the intensity of the event in terms of the spatial extent of convection and the production of high near-surface wind gusts. We further show very high sensitivity to the LBC employed and specifically that simulation fidelity is higher for simulations nested within ERA-Interim than ERA5. Excess CAPE availability in all ensemble members after the Derecho passage leads to excess production of convective cells, wind gusts, cREF > 40dBZ and precipitation during a frontal passage on the subsequent day. This event proved very challenging to forecast in real-time and to reproduce in the 11-member hindcast simulation ensemble presented here. Future work could examine if simulations with other initial and lateral boundary conditions can achieve greater fidelity.

Introduction,

"deep convection disproportionally contributes….", disproportionally does not deliver a good meaning here. Suggest rewording.
"…and three events caused more than 60% of a utilities' customers power outage; a derecho, an ice storm and a hurricane (Shield, 2021)", not three events, should be three types of events.

Response: We regret this typographic error that led to omission of the word "types". **We have added "types of" to the revised manuscript at line 50**.

Section 1.2: this section is for case description. There is too much text in describing the societal and economic impacts but lacking a description of the large-scale and mesoscale metrological environments in which the event developed, which is the key information for the study. Also, there should be observational analysis of this event on storm and wind properties which should be discussed to provide a better background of the events.

Response: The journal description reads as follows: "Natural Hazards and Earth System Sciences (NHESS) is a not-for-profit interdisciplinary and international journal dedicated to the public discussion and open-access publication of high-quality studies and original research on natural hazards and their consequences. Embracing a holistic Earth system science approach, NHESS serves a wide and diverse community of research scientists, practitioners, and decision makers concerned with detection of natural hazards, monitoring and modelling, vulnerability and risk assessment, and the design and implementation of mitigation and adaptation strategies, including economical, societal, and educational aspects." Thus, we felt it was appropriate to include information regarding the economical and societal aspect of the hazard. But we are happy to add further information about the meteorological environment. We thus propose to include the following text at/close to line 76 of the original text (**inserted at lines 82 – 94 of the revised manuscript**):

> Prior research has suggested that Derecho events in the eastern USA are often preceded by large scale troughing over western North America (Cordeira et al. 2017). This was also evident in the June 2012 event, where associated ridging over the eastern US caused extreme near-surface air temperatures and humidity leading to issuance of heatwave advisories (Cattiaux and Yiou, 2013). Rossby wave breaking lead to development of an intense elevated mixed layer (EML, 700-500 hPa) over the central US that subsequently propagated eastwards (Shourd & Kaplan, 2021). The upper-level flow early on June 29 was dominated by ridging over the southeastern US (Figure 12 on the initial conditions) and a near-zonal Jetstream extending from the middle of Wisconsin across the Great Lakes and into New York state, with an embedded jet streak over the northern Great Lakes (Shourd & Kaplan, 2021). Near-surface conditions were dominated by a complex frontal boundary extending approximately west-east across Iowa into Pennsylvania, with very high humidity and high near-surface temperatures just to the south (Figure 12). It is noteworthy that the 12-hour forecast from the NAM model (grid-spacing of 12 km) valid at 8pm (local time) on 29 June 2012 indicated an extensive area of surface-based CAPE in excess of 4000 Jkg^{-1} over the Appalachian Mountains (covering almost all of the state of west Virginia) associated with the eastward propagation of the EML but projected very little precipitation, which contributed to uncertainty in forecasting the location and intensity of the derecho (NOAA, 2013).

Section 2

Section 2.1: (a) the description of model simulations needs some clarification. I am confused by the descriptions at line 160-165. First you described 3 nested domains were used but then said "A single domain configuration and inner nest grid spacing is used in all members of the ensemble…". Are you using two types of domain settings (3 nest domains and single 1.3 km domain)? If so, please clearly describe which domain setup is used for each simulation listed in Table 2? (b) Nudging simulations are not even mentioned here but they are discussed a lot in the Result section.

Author's response to reviewer #1 and reviewer #2:

Response: The text in the revised manuscript (**lines 192 – 193**) has been amended to: "The same domain configuration (i.e. 12, 4, 1.33 km) is used in all members of the ensemble."

Section 2.2. There are better precipitation data than retrieved precipitation rate using Z-R relationship, which in general has a large uncertainty, such as rain gauge data and Stage IV data from NOAA which combines radar and rain gauge measurements.

Response: We thank the reviewer for this suggestion. We note in situ data regarding precipitation from tipping bucket rain gauges operated as part of the NWS ASOS network are included in the original manuscript in Figures 6 and 7. Nevertheless at the reviewers request we have added Stage IV gridded data (that is a combined product of RADAR derived rainfall rates and in situ measurements) into the analysis. E.g. We have updated the fidelity metrics in Table 5 to include a precipitation comparison between WRF and Stage IV. NCEP/EMC 4KM Gridded Data (GRIB) Stage IV Data (Du, 2011). These data were downloaded from https://data.eol.ucar.edu/dataset/21.093 in grib format and converted for processing to netcdf using the NCL command ncl_convert2nc. Hourly precipitation amounts were summed for the entire duration of the Derecho period.

The revised manuscript will thus include; A modified table 5 (see below) and the following text:

- At/near lines 232 in the original manuscript (**inserted at lines 263 – 266 in the revised manuscript):** The NCEP/EMC 4KM Gridded Data Stage IV precipitation product (Du, 2011) which is a blend of RADAR-derived precipitation and in situ measurements is also used in the model fidelity assessment. The spatial fields of accumulated precipitation from the RADAR and the Stage IV product are very similar but the total domain-wide amounts during the Derecho and Frontal periods differ.
- At/near line 258 in the original manuscript (**inserted at lines 300 – 302 in the revised manuscript**): Stage IV precipitation data is also included. Each ensemble member exhibits slightly higher agreement with the Stage IV precipitation product than with RADAR-only total accumulated precipitation during the Derecho period (Table 5).
- The data availability section has been updated to include the following (**inserted at lines 661 – 664 in the revised manuscript**): Stage IV precipitation data (which combines RADAR and rain gauge measurements). NCEP/EMC 4KM Gridded Data (GRIB) Stage IV Data (Du, 2011) were downloaded from https://data.eol.ucar.edu/dataset/21.093 in GRIB format and converted for processing to netCDF using the NCL command 'ncl convert2nc'. Hourly precipitation amounts were summed for the entire duration of the Derecho period.

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Author's response to reviewer #1 and reviewer #2:

Table 5 [**inserted at line 964 in the revised manuscript**]: Metrics of simulation fidelity relative to observations, and convection metrics derived from output from each WRF member during the period of the derecho passage (Derecho period: 29-Jun-2012 21:30:00 to 30-Jun-2012 13:30:00). The metrics of simulation fidelity are described in section 2.2 and are as follows: The Max Gust Ratio: the ratio of the maximum wind gust in any land grid cell from WRF output and observations at the ASOS stations. Total Precip. Ratio: the ratio of the spatial mean total accumulated precipitation from WRF to RADAR and the Stage IV product, respectively, for any grid cell with common coverage. cREF>40 dBZ: the ratio of the spatial extent of grid cells with cREF above 40 dBZ at the peak coverage in WRF and RADAR. The lower portion of the table shows the Spearman rank correlation for the 11 values of each metric (one for each ensemble member). This analysis thus shows the degree to which an ensemble member that exhibit high values of a given metric also generates high values of a second metric. The color-coding used in this table is as follows; for the measures of simulation fidelity table cells colored red have low fidelity, and those indicated by cyan exhibit relatively high fidelity. For all other cells in the table, a background of orange indicates low values, while blue indicates comparatively high values. The saturation of the color indicates relative ordering of the values. The definitions of each convection metric are given in section 2.3.

	Simulation Fidelity				Convection Metric					
	Max Gust Ratio	Total Precip. Ratio (RADAR)	Total Precip. Ratio (Stage IV)	cREF> 40 dBZ Ratio	95% Temperature deviation [-K]	95% SLP deviation [hPa]	Median CAPE loss [J kg^{-1}]	95% -W [ms^{-1}]	Max std(w) height [km]	Z_{R20} [km]
Goddard	0.61	0.206	0.218	0.346	4.23	2.1	876	0.15	8	12.9
Morrison	0.67	0.413	0.435	0.788	3.29	1.85	1532	0.15	8	15.3
Morrison +Hail	0.46	0.016	0.017	0.102	2.12	-0.756	175	0.11	8	9
Thompson	0.26	0.006	0.006	0.044	1.97	0.478	61	0.05	5.6	12.7
NSSL	0.33	0.015	0.015	0.043	3.27	0.238	-42	0.06	6.4	12.8
Milbrandt-626	0.44	0.061	0.064	0.269	3.3	0.596	963	0.09	7.1	13.8
Milbrandt-628	0.57	0.185	0.195	0.391	4.64	3.38	1428	0.09	8.9	13.7
Milbrandt-626-ERA-I	0.63	0.566	0.597	0.844	5.44	2.36	1960	0.15	8.9	14.4
Milbrandt-628-ERA-I	0.69	0.636	0.671	0.945	5.58	2.79	2030	0.14	7.1	14.9
Nudged-ERA5	0.39	0.004	0.004	0.037	1.38	-1.75	575	0.03	7.1	14
Nudged-ERA-I	0.22	0	0	0.004	4.05	-1.22	182	0.01	5.6	11.6
Spearman Rank Correlations	Max Gust Ratio	Total Precip. Ratio (RADAR)	Total Precip. Ratio (Stage IV)	cREF> 40 dBZ Ratio	95% Temperature deviation	95% SLP deviation	Median CAPE Loss	95% -W	Max std(w) height	Z_{R20}
Max Gust Ratio	1									
Total Precip Ratio	0.95	1								
Total Precip Ratio	0.95	1	1							
cREF>40 dBZ Ratio	0.93	0.98	0.98	1						

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Author's response to reviewer #1 and reviewer #2:

95% Temperature	0.72	0.79	0.79	0.78	1					
Spearman Rank Correlations	Max Gust Ratio	Total Precip. Ratio (RADAR)	Total Precip. Ratio (Stage IV)	cREF>40 dBZ Ratio	95% Temperature deviation	95% SLP deviation	Median CAPE Loss	95% -W	Max std(w) height	Z_{R20}
95% SLP deviation	0.75	0.87	0.87	0.92	0.81	1				
Median CAPE Loss	0.81	0.77	0.77	0.81	0.79	0.72	1			
95% -W	0.9	0.92	0.92	0.85	0.64	0.7	0.56	1		
Max std(w) height	0.78	0.68	0.68	0.69	0.47	0.57	0.6	0.75	1	
ZR20	0.65	0.61	0.61	0.61	0.5	0.52	0.81	0.36	0.37	1

Section 2.3, "Grid cells in d03 are classified as containing 'significant hail' in the WRF simulations if there is > 1 mm of hail and/or graupel accumulation, and in RADAR observations for MESH > 5mm. First, how the simulation and observations can be compared since different calculations of significant severe hail (SSH) are used? Second, What are you based on to define SSH with " > 1 mm of hail and/or graupel accumulation" in the simulations? Accumulation over what time period? In literature there are a few methods to calculate the maximum hail size based on model predicted hail/graupel size distribution such as Thompson (J. A. Milbrandt, M. K. Yau, A Multimoment Bulk Microphysics Parameterization. Part III: Control Simulation of a Hailstorm. J. Atmos. Sci. 63, 3114-3136, 2006) and Snook (N. Snook, et al. Prediction and Ensemble Forecast Verification of Hail in the Supercell Storms of 20 May 2013. Weather Forecasting 31, 811-825,2016) methods. These methods make the model-observation comparison more physically consistent. BTW, "significant hail" should be "significant severe hail" based on the conventional terminology from literature. Another comment on this section is that the metrics description for evaluating models takes too much text and can be tightened up.

Response: Thank you for your suggestion. We have reanalysed our output to derive and estimate of the maximum expected size of hail (MESH) in a manner equivalent to that used in the RADAR processing (per Snook (2013)). We have updated our hail threshold to MESH > 25 mm for both WRF and RADAR, corresponding to 'severe hail' in previous work (e.g. Labriola et al., 2019). Figures 6 (**inserted at line 1024 in the revised manuscript**) and 7 (**inserted at line 1029 in the revised manuscript**) and Table 4 (**inserted at line 955 in the revised manuscript)** have been updated accordingly (see below). The revised manuscript will have these revised figures and table.

> **Replacement text** for lines 224 to 226 in the original manuscript **(inserted at lines 259 – 262 in the revised manuscript):** In the current work, a distinction is drawn between hail reports with MESH > 25 mm and those without. This is a diameter threshold has been previously used for identifying 'severe hail' (Labriola et al. 2019).
>
> **Replacement text** for lines 260 to 263 in the original manuscript **(inserted at lines 302 – 307 in the revised manuscript):** Hail occurrence from the WRF ensemble members is also evaluated against RADAR and ASOS observations along with the presence of 'severe hail'. Grid cells in d03 are classified as containing 'severe hail' in the WRF simulations and RADAR observations when MESH > 25mm. MESH for the WRF simulations is estimated using a weighted summation

Author's response to reviewer #1 and reviewer #2:

of hail kinetic energy flux for elevations above the melting layer. Hail kinetic energy fluxes are inferred as a function of reflectivity. This method was developed for use with RADAR data (Witt et al., 1998).

Replacement text for Lines 357 to 371 in the original manuscript **(inserted at lines 410 – 422 in the revised manuscript):** When remapped to the WRF grid, the RADAR data indicate 824 of the almost 90,000 grid cells experienced severe hail during the Derecho period (Table 4). These locations identified by the RADAR detection algorithm as exhibiting hail and MESH > 25 mm are distributed throughout domain d03 (Figure 6). The WRF ensemble members – particularly those that employ the Milbrandt microphysics scheme indicate much greater spatial coverage of hail (Table 4). When the threshold of MESH > 25 mm is applied to the WRF output the occurrence of hail greatly decreases rather few grid cells show hail above this threshold (Table 4). During the Front period the situation is reversed. RADAR observations show limited areas with accumulated precipitation > 40 mm located in bands in the south of the domain, in regions where hail is also indicated by the RADAR detection algorithm (Figure 7). Two-thirds of the domain shows little or no precipitation in either RADAR or ASOS data. All non-nudged WRF ensemble members indicate positive bias in domain-wide precipitation and over-predict the occurrence of hail (Table 4). All four non-nudged ensemble members with the Milbrandt microphysics scheme also indicate multiple locations with MESH > 25 mm. The number of grid cells with RADAR detection of hail shows closest agreement with the Morrison+Hail simulation (Table 4). Using the MESH > 25 mm threshold as indicative of severe hail, the closest accord for the Front period is found for the Nudged-ERA5 ensemble member (Table 4).

Author's response to reviewer #1 and reviewer #2:

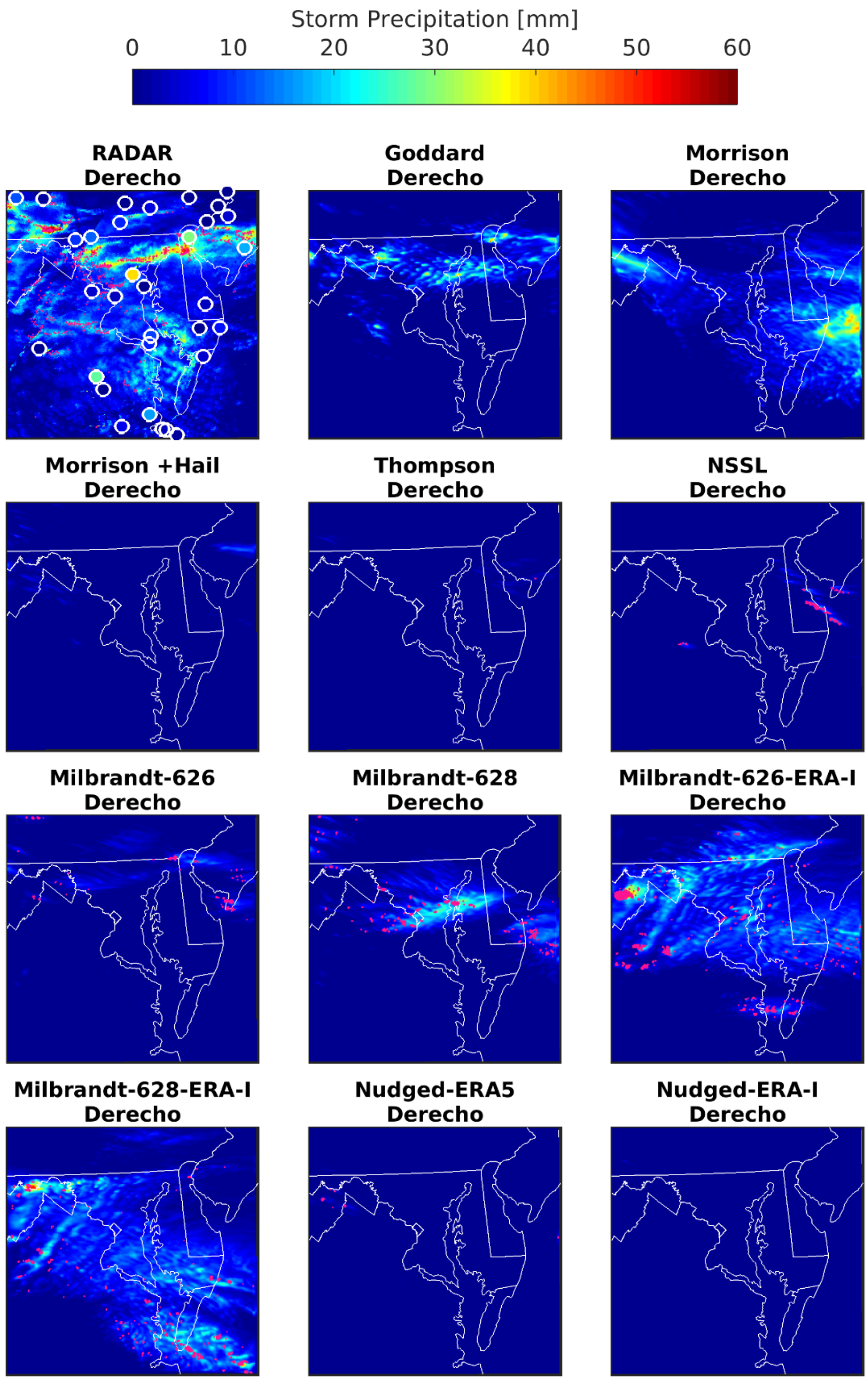

Figure 6 [**inserted at line 1024 in the revised manuscript**]: Total accumulated precipitation (mm) from RADAR observations and each WRF ensemble member during the Derecho period. Grid cells with MESH>25mm are marked in magenta.

Author's response to reviewer #1 and reviewer #2:

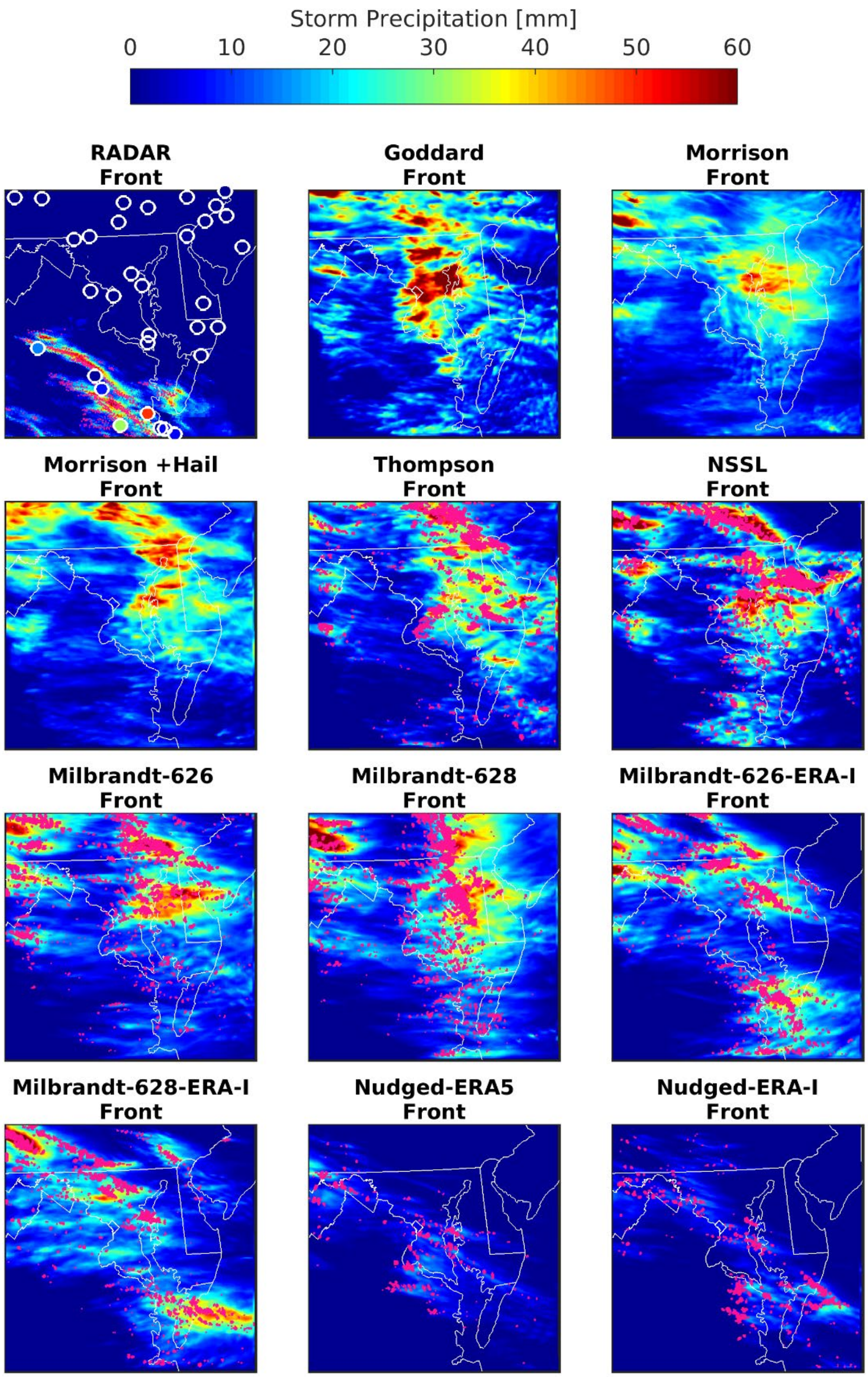

Figure 7 [**inserted at line 1029 in the revised manuscript**]: Total accumulated precipitation (mm) from RADAR observations and each WRF ensemble member during the Front period. Grid cells with MESH>25mm are marked in magenta.

Author's response to reviewer #1 and reviewer #2:

Table 4 [**inserted at line 955 in the revised manuscript**]: Number of grid cells in domain d03 where hail is indicated by the RADARs or present in the WRF simulations during the derecho (Derecho period: 29-Jun-2012 21:30:00 to 30-Jun-2012 13:30:00) and the frontal passage (Front period: 30-Jun-2012 15:20:00 to 01-Jul-2012 14:50:00). Also shown is the number of grid cells with Maximum Estimated Size of Hail (MESH) above 25 mm from the RADAR or WRF. Recall: RADAR detection of hail is re-gridded onto the WRF grid used for domain d03 prior to use in the model evaluation.

	# Grid cells with hail		# Grid cells with MESH > 25 mm	
	Derecho	Front	Derecho	Front
RADAR	3078	2152	824	813
Ensemble member				
Goddard	0	10	0	6
Morrison	0	24	0	0
Morrison +Hail	3000	74398	0	0
Thompson	10	8996	2	4909
NSSL	7446	79890	135	5907
Milbrandt-626	16368	78276	167	5687
Milbrandt-628	26183	77415	436	6461
Milbrandt-626-ERA-I	54406	68899	782	4928
Milbrandt-628-ERA-I	63695	67671	568	4028
Nudged-ERA5	2428	37913	21	1226
Nudged-ERA-I	195	37692	0	2071

Section 3,
Figure 4, the simulations with changes of different microphysics only (Goddard, Morrison, Morrison+hail, Thompson, NSSL, Milbrandt-626) totally fails to simulate the convective systems except Morrison captured the linear system. Switching to another microphysics scheme in WRF usually does not make such a large storm system totally disappear (never experienced or saw this in literature). The coupling of those microphysics scheme with WRF should have no problem so it is strange this happened. What is especially suspicious is when switching the graupel option to hail in Morrison scheme, the large linear MCS system disappeared. This would not be possible in a few days of forecasting simulations since slight differences in microphysics should not have such a huge upscale effect on mesoscale systems in a few days.

Response: As noted above, one of the limitations with this (and most) modeling studies is the introduction of small-scale perturbations at t=0 that contribute to upscale growth and drive different convective forecast realizations. It is not unprecedented or unreasonable to expect sensitivity between physics schemes in WRF, and there are numerous studies in the literature that have explored this. Indeed, a study of the differences in the mass and number concentrations (where present) in each of the schemes illustrates the likelihood in the varying degree of skill that each scheme can predict the sub-grid scale processes. Again, as noted above, the use of the hail switch leads to a reduced area of reflectivity (e.g. see Morrison et al. 2015 JAS) and can indeed have large enough upscale growth from t=0 to affect system development and propagation, which is evident in the analysis. Furthermore, the noted improvement in the 28 June 00Z initialized cases is further evidence to suggest the model predictability of this event is improved the closer the model start date is to the derecho genesis on 29 June. This makes sense when appreciating the role of convective error growth over time, thus the cases initialized on 26 June 00Z would therefore be more prone to some amount of model error.

Shepherd T.J., Letson F., Barthelmie R.J. and Pryor S.C. How well are hazards associated with derechos reproduced in regional climate simulations? *Natural Hazards and Earth System Sciences Discussions (*nhess-2021-373)

Author's response to reviewer #1 and reviewer #2:

Furthermore, based on Figures 4-7, none of the simulations can simulate both derecho and front stages of the observed system, then why the simulations fail like this should be the first priority of the study.

This is indeed a key motivation for this manuscript and for section 3.2 where we seek to advance understanding of the key precursors (e.g. CAPE and vertical shear) and outcomes of the Derecho and our enhanced discussion of the initial conditions.

Figure 8, why not plot the radar measurements?

Response: We thank the reviewer for this suggestion and have included the RADAR measurements. As the reviewer will be aware the NWS RADAR scan at (typically) six elevation angles and thus the resulting data are not on the same 3D grid as WRF. Thus, we have taken the base reflectivity data from each 360º arc scan at each elevation angle from each RADAR at t_p and used them to derive vertical profiles of reflectivity. We note that the RADAR observations do not provide coverage for the entire vertical structure, but we have included the measurements to the available level (these are now included on Figure 8 (**inserted at line 1034 in the revised manuscript**), see below).
We have also updated Figure S1 (**inserted at line 3 in the revised supplemental materials**) to show RADAR observations for the Front period (see Figure S1 below).

We envisage replacing both Figure 8 and Figure S1 and including the following text at/near line 374 in the original manuscript (**inserted at lines 439 – 444 in the revised manuscript**):

> Vertical profiles of base reflectivity data from each 360º arc scan at each elevation angle from each RADAR at t_p are also shown in Figure 8. Though this observationally constrained vertical profile is based on considerably lower data volumes than in the WRF output, it is worthy of note that the peak in reflectivity in the RADAR is located lower in the atmosphere than in most of the WRF ensemble members. Further, a greater fraction of the reflectivity values at 12 km (the highest height from which any RADAR data are available) from the RADAR observations are > 20 dBZ than in many, but not all, of the ensemble members.

Shepherd T.J., Letson F., Barthelmie R.J. and Pryor S.C. How well are hazards associated with derechos reproduced in regional climate simulations? *Natural Hazards and Earth System Sciences Discussions (*nhess-2021-373)

Author's response to reviewer #1 and reviewer #2:

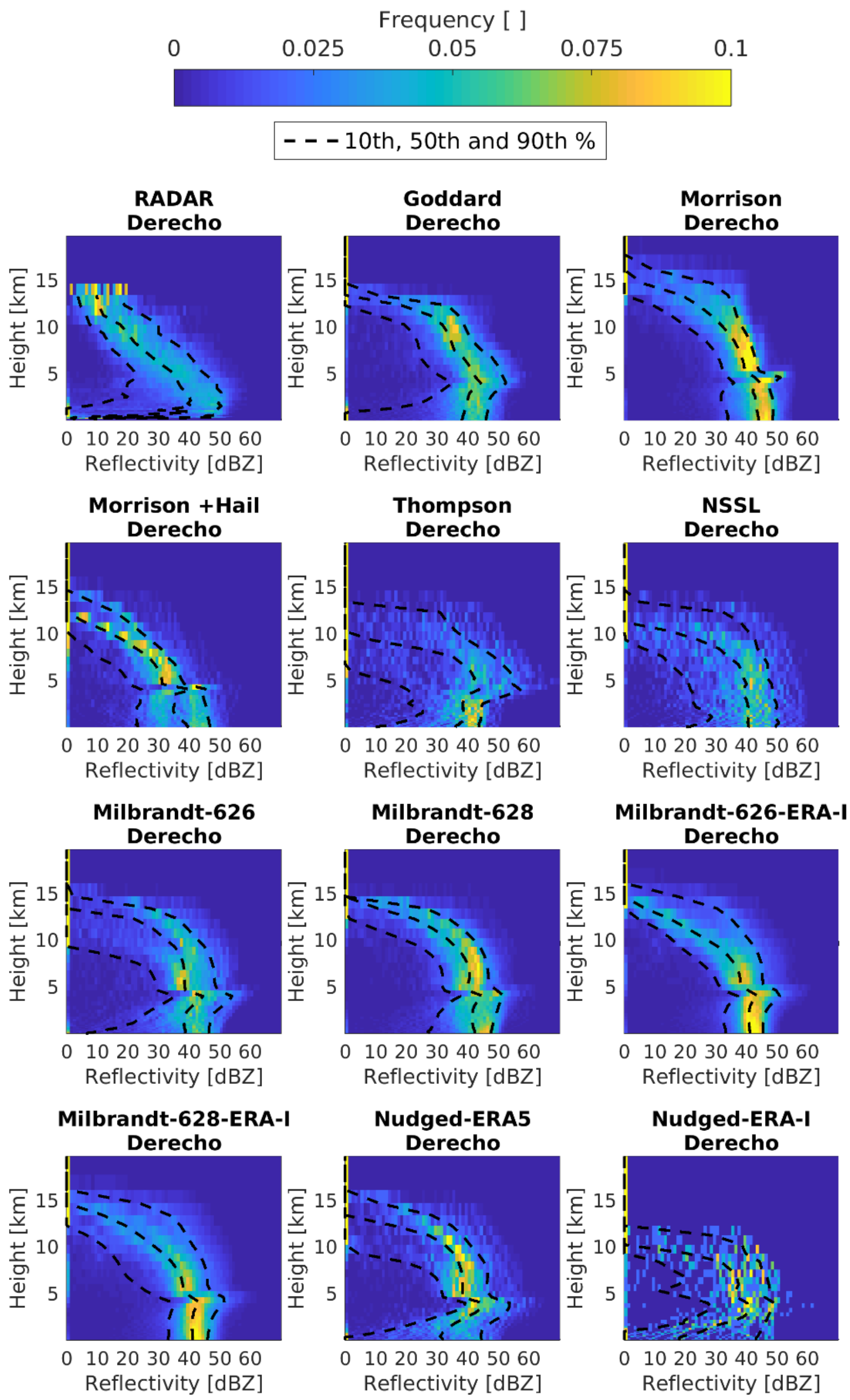

Figure 8 [**inserted at line 1034 in the revised manuscript**]: Probability distributions of base reflectivity from RADAR and derived RADAR reflectivity from each WRF ensemble member at each model height at t_p during the Derecho period. The plot shows the frequency with which a given reflectivity is observed at a given height in output for all domain d03 grid cells where cREF > 40 dBZ. Dotted lines show the 10^{th}, 50^{th} and 90^{th} percentile reflectivity at each height.

Shepherd T.J., Letson F., Barthelmie R.J. and Pryor S.C. How well are hazards associated with derechos reproduced in regional climate simulations? *Natural Hazards and Earth System Sciences Discussions (*nhess-2021-373)

Author's response to reviewer #1 and reviewer #2:

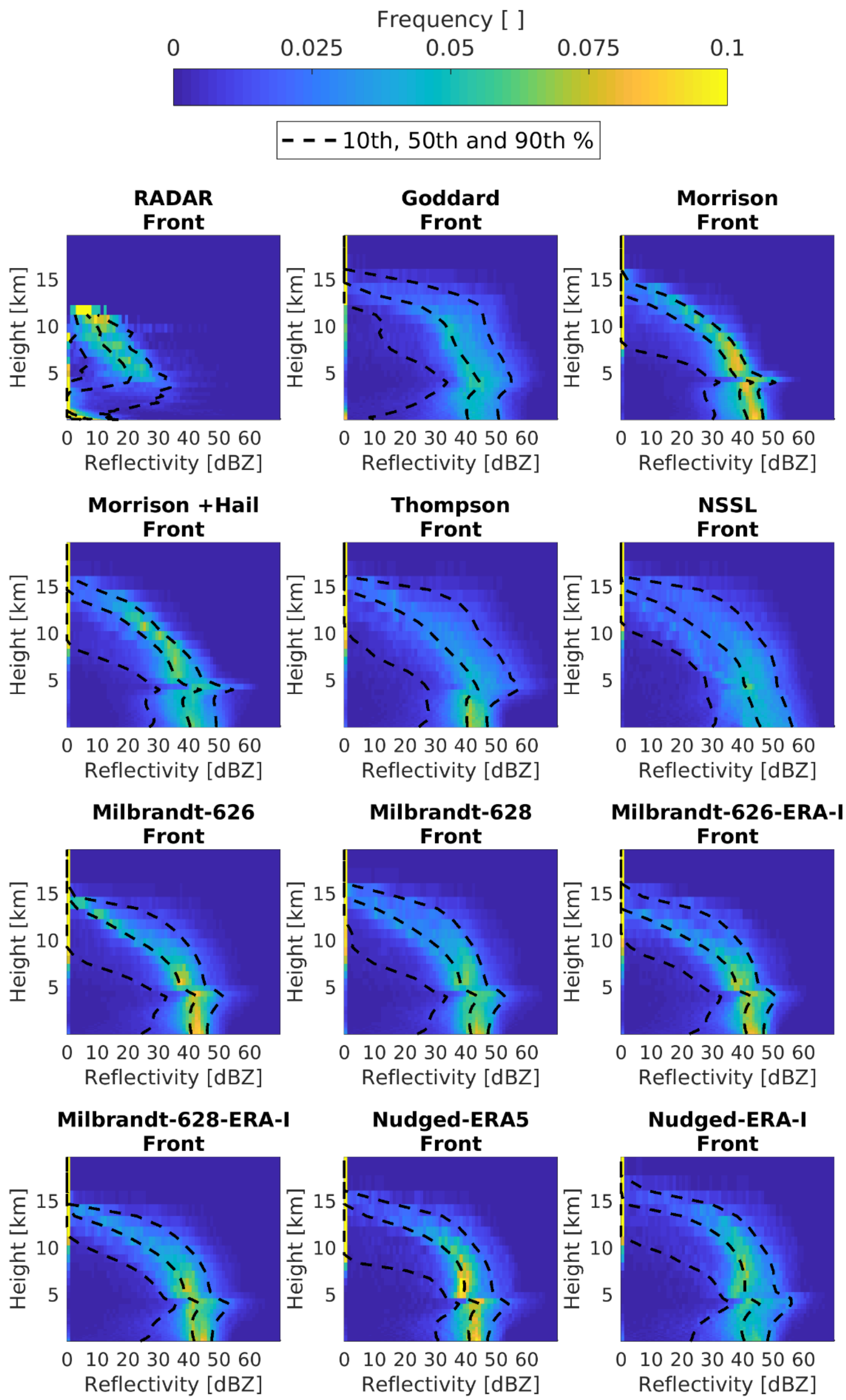

Figure S1 [**inserted at line 3 in the revised supplemental materials**]: Probability distributions of base reflectivity from RADAR and derived RADAR reflectivity from each WRF ensemble member at each model height at t_p during the Front period. The plot shows the frequency with which a given reflectivity is observed at a given height in output for all domain d03 grid cells where cREF > 40 dBZ. Dotted lines show the 10th, 50th and 90th percentile reflectivity at each height.

Figures 9 -11, because the observed MCS was not captured in most of the simulations, one can see the simulated wind speeds are also way off. I do not see a point to intercompare convective winds, cold pools, or other storm related properties since the mesoscale system does not even exist in the model simulations or the basic mesoscale storm is totally wrong as shown in Figures 4-7. Therefore, I did not review Section 3.2 "Linking fidelity to metrics of CAPE, downbursts, and cold pool generation".

Response: Now that we have established the robustness of the simulations (in terms of numerical stability), and included the results of the additional simulations, we hope that the reviewer will be able to go back and read this section. Based on the objectives and our explanations for the varying sensitivity of the storm dynamics to the microphysics schemes used should now be more coherent. Recall in this section we are describing and evaluating a suite of properties and hazards and seek to illustrate where partial fidelity exists, how that relates to the depiction of the surface hazards.

Since the sensitivity to two lateral boundary data (ERA5 and ERA-Interim) is opposite to previous studies (many studies showed ERA5 data is improved on ERA-Interim), the authors need to evaluate both datasets with observations to show this is an exception that ERA5 performs worse than ERA-Interim. Otherwise, this will make people doubt if the simulations are done correctly.

Response: We refer the reviewer to both lines 409 – 416 in the original text, and Figure S2 of the supplementary materials where we have originally undertaken an analysis of sea level pressure, temperature at 2m, and specific humidity at 2m. Upon the reviewer's suggestion, however, we have remade and **improved Figure S2 and moved this revised figure into the main text (inserted as Figure 12 in the revised manuscript at line 1061**). We now include a more comprehensive assessment of the initial conditions and direct comparison to rawinsonde observations (i.e. atmospheric sounding data collated by the University of Wyoming http://weather.uwyo.edu/upperair/sounding.html). We now have a figure panel (Figure 12) with 5 separate plots, one each for sea level pressure, elevated mixed layer (EML), 500 hPa temperature, 500 hPa geopotential height, and 500 hPa relative humidity. We justify this in the following two paragraphs, and this is text that will be included in the revised manuscript. The figure (see new Figure 12 in the revised manuscript, revised from the SM Figure S2) is now included in the main text rather than in the supplementary materials. This figure is a summary of our enhanced evaluation of the initial conditions. In order to introduce it we will add the following text to the manuscript:

> At near line 212 in the original manuscript (**inserted at lines 243 – 247 in the revised manuscript**): We also employ data from all 28 rawinsondes within the simulation domain in the fidelity assessment of the initial conditions from each reanalysis product and start time. In these analyses the conditions on two geopotential surfaces (700 hPa and 500 hPa) as derived using WRF real from the ERA5 and ERA-Interim reanalysis products are interpolated to these pressure levels using the wrf_interp program (available at: https://github.com/pick2510/wrf_interp) and the rawinsonde observations for the closest release time.
>
> At/near line 419 in the original manuscript (**inserted at lines 489 – 501 in the revised manuscript**): Evaluation of the initial conditions indicates a high-degree of similarity between the two reanalysis products on 26 and 28 June for most properties (Figure 12). However, as described above, development of an intense elevated mixed layer (EML, 700-500 hPa) over the central US that subsequently propagated eastwards (Shourd and Kaplan, 2021) appears to have

Author's response to reviewer #1 and reviewer #2:

been a key ingredient in development of this Derecho. Earlier work (Banacos and Ekster, 2010) employed a definition of an EML as a layer of depth > 200 hPa with both a steep lapse rate (temperature declines of over 8°C per km) and an increase in the RH with height. Figure 12 shows the lapse rate in the four sets of IC and indicates that while both data sets correctly (relative to output from NOAA WRF-Rapid Refresh model presented in Shourd and Kaplan, 2021) indicate relatively low lapse rates at 0000Z 26 June (when the region with the EML was displaced further west), using the combined definition of a strong lapse rate and a strong gradient of RH (a 20% difference across the layer), the EML is, in both reanalysis products, displaced too far north at 0000Z 28 June relative to NOAA WRF-Rapid Refresh model simulations presented in Shourd and Kaplan (2021). The EML is, however, more consistent (across the two components) and more coherent in space in ERA-Interim. This may provide a partial explanation for why simulations with ERA-Interim initial and lateral boundary conditions exhibit higher fidelity with respect to aspects of the Derecho.

Author's response to reviewer #1 and reviewer #2:

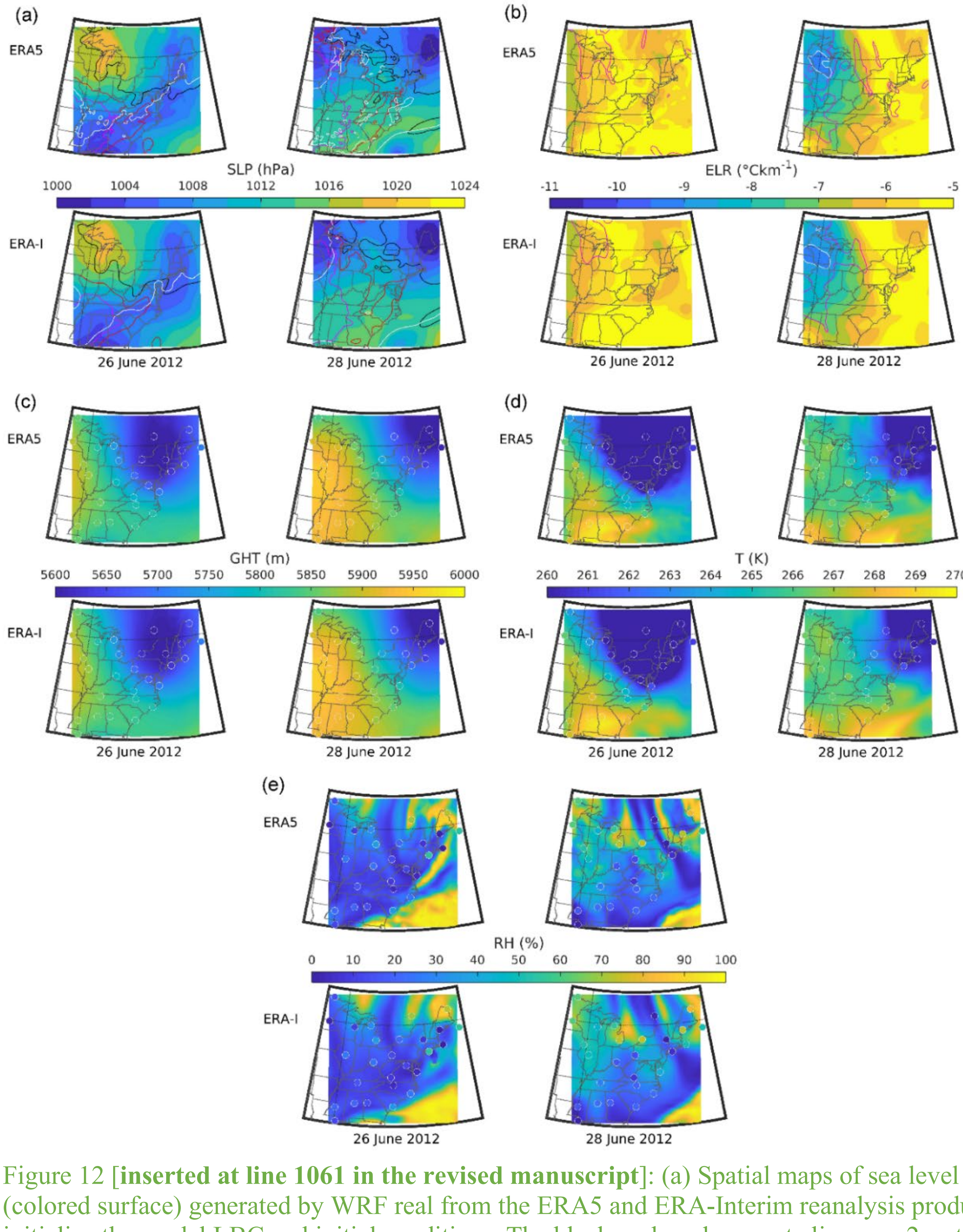

Figure 12 [**inserted at line 1061 in the revised manuscript**]: (a) Spatial maps of sea level pressure (colored surface) generated by WRF real from the ERA5 and ERA-Interim reanalysis products used to initialize the model LBC and initial conditions. The black, red, and magenta lines are 2-m temperature of 295 K, 300 K, and 305 K respectively. The white line represents specific humidity at 2-m of 12.5 g/kg. (b) Filled contours of lapse rates (700-500 hPa) with the -9°C/km highlighted by the white outline. Also shown by the magenta isoline is the area in which the RH increased by 20% over this layer. (c) 500 hPa geopotential height in meters. (d) 500 hPa temperature in Kelvin. (e) 500 hPa relative humidity in %. Plots in (c), (d), and (e) contain rawinsonde observations (filled cicles). In all the plots, WRF real output is used from all 3 domains.

Author's response to reviewer #1 and reviewer #2:

As a further assessment of the initial conditions, we have also examined MU-CAPE from soundings, for direct comparison against model MU-CAPE. Figure S3 (now Figure S2 in the revised supplemental materials) and Figure S7 (now Figure S6 in the revised supplemental materials) have been updated to include this data. Note that the scale for Figure S3 has changed from 0 – 5000 to 0 – 6000 J kg^{-1}. The following text will be inserted into the revised manuscript:

> At/near line 420 in the original manuscript (**lines 520 – 528 in the revised manuscript**): MU-CAPE from the SHARPpy software (Blumberg et al., 2017) is defined slightly differently than in the python WRF analysis codes, in that it is the parcel with the maximum equivalent potential temperature in the lowest 400 mb, thus the values are not directly comparable. Nevertheless, high values are indicative of presence of significant CAPE. Consistent with past summaries of the environment in which the derecho was manifest, rawinsonde data from the two stations (KIAD (38.968N, -77.369E) and KWAL (38.018N and -75.236E)) within domain d03 indicate MU-CAPE values at tp-3 (from RADAR) (i.e. 0000 UTC 30 June) of 6871 J/kg and 4735 J/kg (Figure S2). The surface to 6 km shear at that time are 17.2 m/s and 11.5 m/s respectively, which is consistent with the relatively weak shear evident in the WRF ensemble members (Figure S6). MU-CAPE at KIAD and KWAL dropped to 51 and 60 J/kg, respectively in the 1200 UTC 30 June sounding. This further emphasizes the profound underestimation of CAPE consumption in the WRF ensemble during the passage of the derecho.

Shepherd T.J., Letson F., Barthelmie R.J. and Pryor S.C. How well are hazards associated with derechos reproduced in regional climate simulations? *Natural Hazards and Earth System Sciences Discussions (*nhess-2021-373)

Author's response to reviewer #1 and reviewer #2:

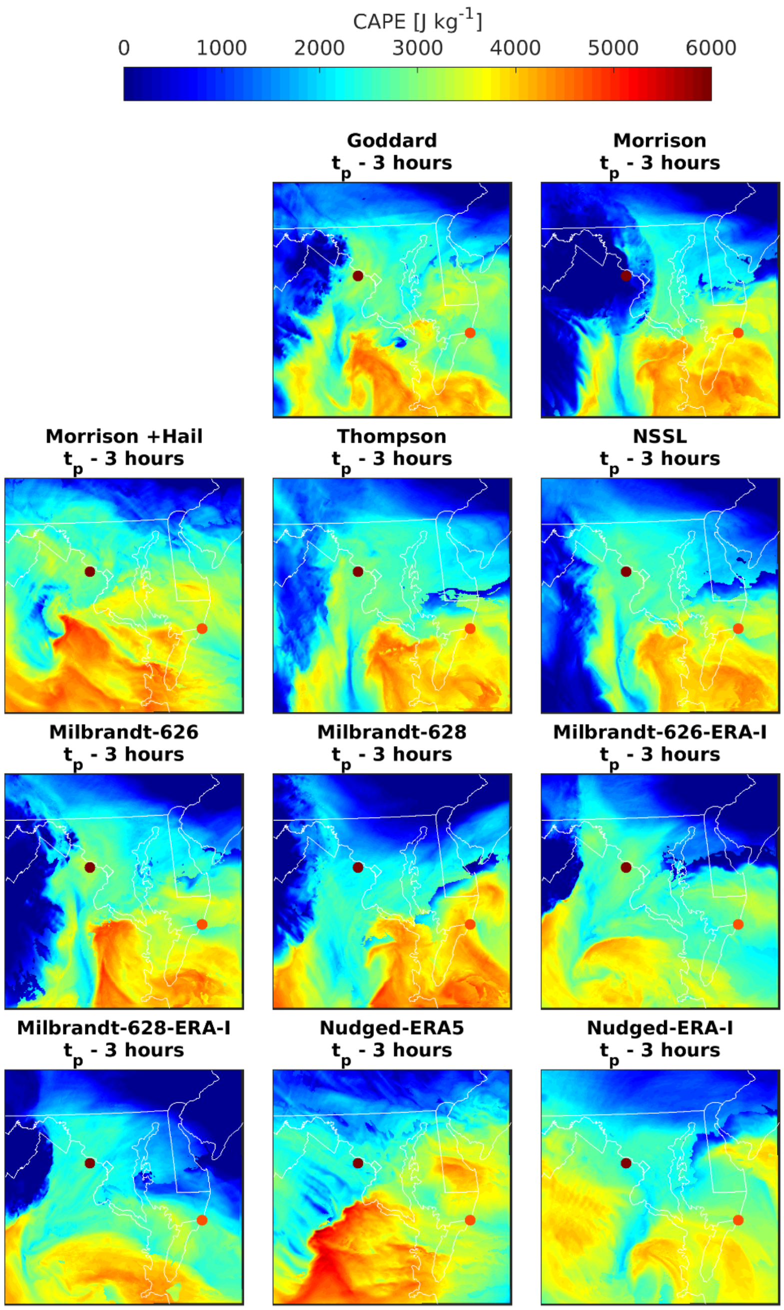

Figure S2 [**inserted as Figure S2 at line 22 in the revised supplemental materials**]: Spatial patterns of MU-CAPE at t_p-3 (i.e. 3 hours prior to the time of peak spatial extent of cREF > 40 dBZ during the Derecho period) over domain d03 for all ensemble members. These panels are also shown in Figure 15 of the main text but are included again here, enlarged for visibility. MU-CAPE as computed from the SHARPpy program based on rawinsonde data at tp-3 (define from RADAR) (i.e. 0000 UTC 30 June) at KIAD (38.968N, -77.369E) and KWAL (38.018N and -75.236E) are shown by the filled circles.

Author's response to reviewer #1 and reviewer #2:

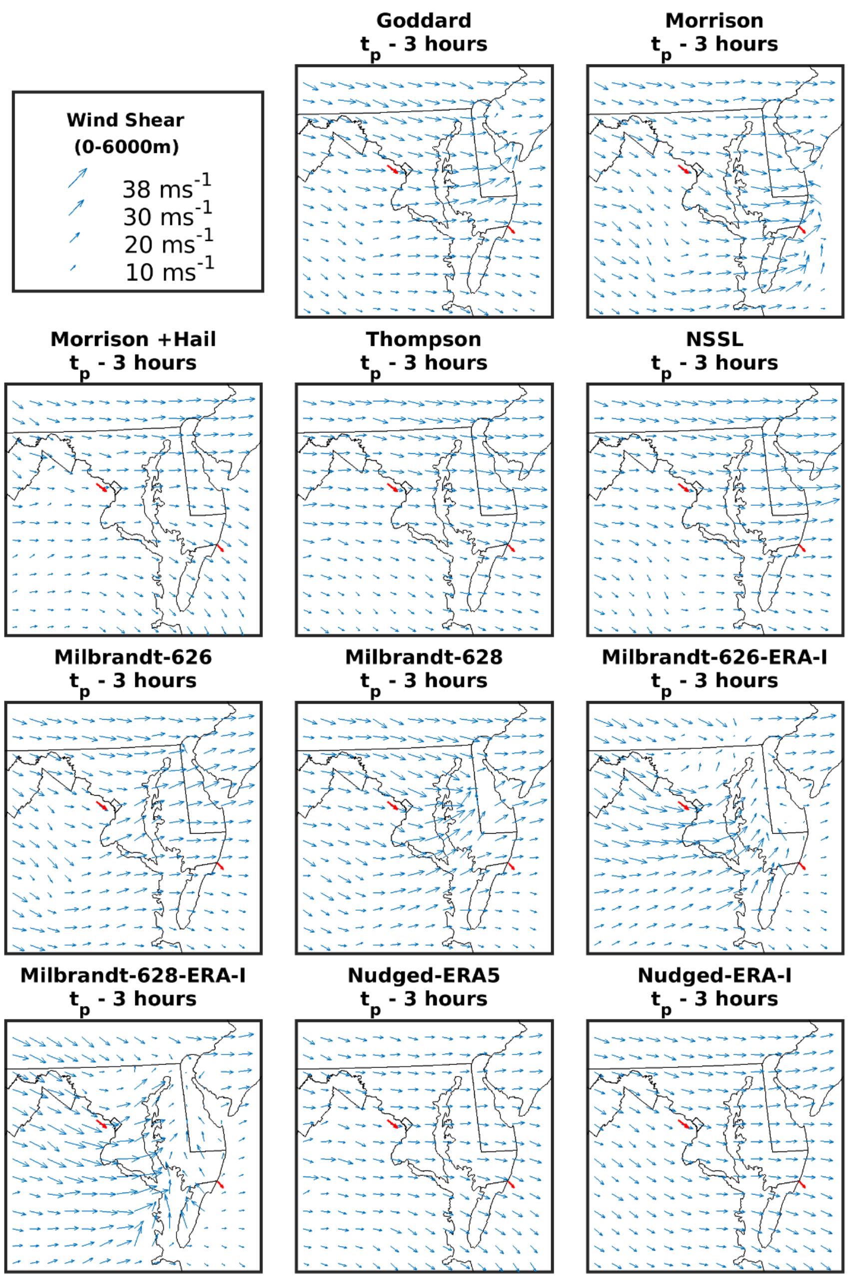

Figure S6 [**inserted as Figure S6 at line 45 in the revised supplemental materials**]: Total wind shear between the ground and 6000 m (S6) at t_p (the time of peak spatial extent of cREF > 40 dBZ during the Derecho period) for each ensemble member. These panels are also shown in Figure 15 of the main text but are included again here, enlarged for visibility. Observed shear from the surface to 6 km at the KIAD (38.968N, -77.369E) and KWAL (38.018N and -75.236E) stations are shown by the red arrows.

Shepherd T.J., Letson F., Barthelmie R.J. and Pryor S.C. How well are hazards associated with derechos reproduced in regional climate simulations? *Natural Hazards and Earth System Sciences Discussions (*nhess-2021-373)

Author's response to reviewer #1 and reviewer #2:

References

Ahrens, B. and Leps, N. (2021). Sensitivity of Convection Permitting Simulations to Lateral Boundary Conditions in Idealised Experiments. *Earth and Space Science Open Archive*; Washington, Feb 28, 2021. DOI:10.1002/essoar.10506295.1

Banacos, P. C., & Ekster, M. L. (2010). The association of the elevated mixed layer with significant severe weather events in the northeastern United States. *Weather and Forecasting*, *25*(4), 1082-1102.

Blumberg, W. G., Halbert, K. T., Supinie, T. A., Marsh, P. T., Thompson, R. L., & Hart, J. A. (2017). SHARPpy: An open-source sounding analysis toolkit for the atmospheric sciences. *Bulletin of the American Meteorological Society*, *98*(8), 1625-1636.

Cattiaux, J., & Yiou, P. (2013). US heat waves of spring and summer 2012 from the flow-analogue perspective. *Bulletin of the American Meteorological Society*, *94*(9), S10-S13.

Cordeira, J. M., Metz, N. D., Howarth, M. E., & Galarneau Jr, T. J. (2017). Multiscale upstream and in situ precursors to the elevated mixed layer and high-impact weather over the Midwest United States. *Weather and Forecasting*, *32*(3), 905-923.

Du, J. 2011. NCEP/EMC 4KM Gridded Data (GRIB) Stage IV Data. Version 1.0. UCAR/NCAR - Earth Observing Laboratory. https://doi.org/10.5065/D6PG1QDD. Accessed 08 Feb 2022.

Fierro, A. O., Gao, J., Ziegler, C. L., Mansell, E. R., MacGorman, D. R., and Dembek, S. R. (2014). Evaluation of a cloud-scale lightning data assimilation technique and a 3DVAR method for the analysis and short-term forecast of the 29 June 2012 derecho event, *Monthly Weather Review*, 142, 183-202.

Hacker, J. P., Exby, J., Gill, D., Jimenez, I., Maltzahn, C., See, T., ... & Fossell, K. (2017). A containerized mesoscale model and analysis toolkit to accelerate classroom learning, collaborative research, and uncertainty quantification. *Bulletin of the American Meteorological Society*, *98*(6), 1129-1138.

Labriola, J., Snook, N., Xue, M., & Thomas, K. W. (2019). Forecasting the 8 May 2017 severe hail storm in Denver, Colorado, at a convection-allowing resolution: Understanding rimed ice treatments in multimoment microphysics schemes and their effects on hail size forecasts. *Monthly Weather Review*, 147(8), 3045-3068.

Li, R., Liu, L., Yang, G., Zhang, C., & Wang, B. (2016). Bitwise identical compiling setup: Prospective for reproducibility and reliability of Earth system modeling. *Geoscientific Model Development*, **9**(2), 731–748. https://doi.org/10.5194/gmd-9-731-2016

Lighezzolo, A., Martina A., Zigarán, G., Viscardi, D., Lio, E., Rodriguez, A., Montamat, I., et al. (2018). "WRF model-sensitivity experiments to computational environment changes." In *2018 IEEE Biennial Congress of Argentina (ARGENCON)*, pp. 1-7. IEEE. doi: 10.1109/ARGENCON.2018.8645986

Morrison, H., Milbrandt, J. A., Bryan, G. H., Ikeda, K., Tessendorf, S. A., and Thompson, G. (2015). Parameterization of Cloud Microphysics Based on the Prediction of Bulk Ice Particle Properties. Part II:

Shepherd T.J., Letson F., Barthelmie R.J. and Pryor S.C. How well are hazards associated with derechos reproduced in regional climate simulations? *Natural Hazards and Earth System Sciences Discussions (*nhess-2021-373)

Author's response to reviewer #1 and reviewer #2:

Case Study Comparisons with Observations and Other Schemes, *Journal of the Atmospheric Sciences*, 72, 312-339, 10.1175/jas-d-14-0066.1.

NOAA. The Historic Derecho of 29 June 2012; Service Assessment, U.S. Department of Commerce, NOAA National Weather Service: Silver Spring, MD, USA, 2013; p. 61

Shourd, K. N., & Kaplan, M. L. (2021). The Multiscale Dynamics of the 29 June 2012 Super Derecho. *Climate*, *9*(11), 155.

Witt, A., Eilts, M. D., Stumpf, G. J., Johnson, J. T., Mitchell, E. D. W., & Thomas, K. W. (1998). An enhanced hail detection algorithm for the WSR-88D. *Weather and Forecasting*, 13(2), 286-303.

Shepherd T.J., Letson F., Barthelmie R.J. and Pryor S.C. How well are hazards associated with derechos reproduced in regional climate simulations? *Natural Hazards and Earth System Sciences Discussions (*nhess-2021-373)

Author's response to reviewer #1 and reviewer #2:

Namelist files for each simulation

Morrison

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Author's response to reviewer #1 and reviewer #2:

```
sf_surface_physics          = 2,     2,     2,
bl_pbl_physics              = 5,     5,     5,
bldt                        = 0,     0,     0,
cu_physics                  = 1,     0,     0,
cudt                        = 5,
isfflx                      = 1,
ifsnow                      = 1,
icloud                      = 1,
surface_input_source        = 3,
num_soil_layers             = 4,
num_land_cat                = 21,
sf_urban_physics            = 0,     0,     0,
bl_mynn_tkebudget           = 1,     1,     1,
bl_mynn_tkeadvect           = .true., .true., .true.,
rdmaxalb                    = .false.,
sst_update                  = 1,
tmn_update                  = 1,
usemonalb                   = .true.,
lagday                      = 150,
sst_skin                    = 1,
slope_rad                   = 1,  1,  1,
do_radar_ref                = 1,
prec_acc_dt                 = 60., 10., 10.,
fractional_seaice           = 1,
seaice_threshold            = 0.,
/
&noah_mp
dveg                        = 4,
opt_crs                     = 1,
opt_btr                     = 2,
opt_run                     = 3,
opt_sfc                     = 1,
opt_frz                     = 1,
opt_inf                     = 1,
opt_rad                     = 3,
opt_alb                     = 2,
opt_snf                     = 4,
opt_tbot                    = 1,
opt_stc                     = 3,
/
&dynamics
w_damping                   = 1,
diff_opt                    = 1,      1,      1,
km_opt                      = 4,      4,      4,
diff_6th_opt                = 0,      0,      0,
diff_6th_factor             = 0.12,   0.12,   0.12,
base_temp                   = 290.
```

Author's response to reviewer #1 and reviewer #2:

```
damp_opt                    = 0,
zdamp                       = 5000.,  5000.,  5000.,
dampcoef                    = 0.01,    0.01,  0.01,
khdif                       = 0,      0,
kvdif                       = 0,      0,
non_hydrostatic             = .true., .true., .true.,
/
&bdy_control
spec_bdy_width              = 5,
spec_zone                   = 1,
relax_zone                  = 4,
spec_exp                    = 0.13
specified                   = .true., .false., .false.,
nested                      = .false., .true., .true.,
/
&grib2
/
&namelist_quilt
nio_tasks_per_group = 0,
nio_groups = 1,
/
```

Morrison + Hail

```
&time_control
 run_days                          = 6,
 run_hours                         = 0,
 run_minutes                       = 0,
 run_seconds                       = 0,
 start_year                        = 2012, 2012, 2012,
 start_month                       = 06,   06,   06,
 start_day                         = 26,   26,   26,
 start_hour                        = 00,   00,   00,
 start_minute                      = 00,   00,   00,
 start_second                      = 00,   00,   00,
 end_year                          = 2012, 2012, 2012,
 end_month                         = 07,   07,   07,
 end_day                           = 02,   02,   02,
 end_hour                          = 00,   00,   00,
 end_minute                        = 00,   00,   00,
 end_second                        = 00,   00,   00,
 interval_seconds                  = 21600
 input_from_file                   = .true.,.true.,.true.,
 history_interval                  = 60,  10, 10,
 frames_per_outfile                = 1,  1, 1,
 history_outname                   =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfout_d<domain>_<date>"
 restart                           = .false.,
 restart_interval                  = 1440,
 override_restart_timers           = .true.,
 io_form_history                   = 11
 io_form_restart                   = 2
 io_form_input                     = 2
 io_form_boundary                  = 11
 io_form_auxinput2                 = 11
 io_form_auxhist2                  = 11
 debug_level                       = 10
 nocolons                          = .true.,
 auxinput4_inname                  = "wrflowinp_d<domain>",
 auxinput4_interval                = 1440,  1440,  1440,
 io_form_auxinput4                 = 2,
 auxinput1_inname                  = "/data/derecho/met_files/ERA5/met_em.d<domain>.<date>"
 iofields_filename                 = "my_file_d01.txt", "my_file_d02.txt", "my_file_d03.txt",
 ignore_iofields_warning           = .true.,
 auxhist1_outname                  =
"/data/derecho/WRF_output/NE_2012/aux1/auxhist1_d<domain>_<date>"
 auxhist1_interval                 = 60,  60,  60,
 frames_per_auxhist1               = 1,  1,  1,
 io_form_auxhist1                  = 11,
 output_diagnostics                = 1,
```

```
 auxhist3_outname                   =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfxtrm_d<domain>_<date>"
 auxhist3_interval                  = 60, 10, 10,
 frames_per_auxhist3                = 1, 1, 1,
 io_form_auxhist3                   = 11,
/
 &domains
 time_step                          = 30,
 time_step_fract_num                = 0,
 time_step_fract_den                = 1,
 max_dom                            = 3,
 e_we                               = 175,    262,   295,
 e_sn                               = 175,    262,   295,
 e_vert                             = 41,     41,    41,
 p_top_requested                    = 5000,
 sfcp_to_sfcp                       = .true.,
 num_metgrid_levels                 = 38,
 num_metgrid_soil_levels            = 4,
 dx                                 = 12000, 4000, 1333.33,
 dy                                 = 12000, 4000, 1333.33,
 grid_id                            = 1,     2,    3,
 parent_id                          = 1,     1,    2,
 i_parent_start                     = 1,     60,   105,
 j_parent_start                     = 1,     35,   75,
 parent_grid_ratio                  = 1,     3,    3,
 parent_time_step_ratio             = 1,     3,    3,
 feedback                           = 0,
 max_ts_locs                        = 0,
 eta_levels                         = 1.0000 , 0.9958 , 0.9916 , 0.9874 , 0.9832 ,
                                      0.9790 , 0.9749 , 0.9707 , 0.9661 , 0.9609 ,
                                      0.9549 , 0.9480 , 0.9398 , 0.9303 , 0.9189 ,
                                      0.9054 , 0.8894 , 0.8704 , 0.8481 , 0.8221 ,
                                      0.7922 , 0.7583 , 0.7205 , 0.6791 , 0.6346 ,
                                      0.5877 , 0.5393 , 0.4900 , 0.4407 , 0.3922 ,
                                      0.3450 , 0.2996 , 0.2564 , 0.2156 , 0.1773 ,
                                      0.1417 , 0.1086 , 0.0755 , 0.0475 , 0.0224 ,
                                      0.0000,
/
 &physics
 mp_physics                         = 10,     10,     10,
 ra_lw_physics                      = 1,      1,      1,
 ra_sw_physics                      = 1,      1,      1,
 radt                               = 10,     10,     10,
 sf_sfclay_physics                  = 1,      1,      1,
 sf_surface_physics                 = 2,      2,      2,
 bl_pbl_physics                     = 5,      5,      5,
 bldt                               = 0,      0,      0,
```

Author's response to reviewer #1 and reviewer #2:

```
 cu_physics                = 1,     0,     0,
 cudt                      = 5,
 isfflx                    = 1,
 ifsnow                    = 1,
 icloud                    = 1,
 surface_input_source      = 3,
 num_soil_layers           = 4,
 num_land_cat              = 21,
 sf_urban_physics          = 0,     0,     0,
 bl_mynn_tkebudget         = 1,     1,     1,
 bl_mynn_tkeadvect         = .true., .true., .true.,
 rdmaxalb                  = .false.,
 sst_update                = 1,
 tmn_update                = 1,
 usemonalb                 = .true.,
 lagday                    = 150,
 sst_skin                  = 1,
 slope_rad                 = 1,  1,  1,
 do_radar_ref              = 1,
 prec_acc_dt               = 60., 10., 10.,
 fractional_seaice         = 1,
 seaice_threshold          = 0.,
 hail_opt                  = 1,
 /
 &noah_mp
 dveg                      = 4,
 opt_crs                   = 1,
 opt_btr                   = 2,
 opt_run                   = 3,
 opt_sfc                   = 1,
 opt_frz                   = 1,
 opt_inf                   = 1,
 opt_rad                   = 3,
 opt_alb                   = 2,
 opt_snf                   = 4,
 opt_tbot                  = 1,
 opt_stc                   = 3,
/
 &dynamics
 w_damping                 = 1,
 diff_opt                  = 1,      1,      1,
 km_opt                    = 4,      4,      4,
 diff_6th_opt              = 0,      0,      0,
 diff_6th_factor           = 0.12,   0.12,   0.12,
 base_temp                 = 290.
 damp_opt                  = 0,
 zdamp                     = 5000.,  5000.,  5000.,
```

Author's response to reviewer #1 and reviewer #2:

```
dampcoef                   = 0.01,    0.01,  0.01,
khdif                      = 0,      0,
kvdif                      = 0,      0,
non_hydrostatic            = .true., .true., .true.,
/
&bdy_control
spec_bdy_width             = 5,
spec_zone                  = 1,
relax_zone                 = 4,
spec_exp                   = 0.13
specified                  = .true., .false., .false.,
nested                     = .false., .true., .true.,
/
&grib2
/
&namelist_quilt
nio_tasks_per_group = 0,
nio_groups = 1,
/
```

Shepherd T.J., Letson F., Barthelmie R.J. and Pryor S.C. How well are hazards associated with derechos reproduced in regional climate simulations? *Natural Hazards and Earth System Sciences Discussions (*nhess-2021-373)

Author's response to reviewer #1 and reviewer #2:

Morrison-intel (Run on NERSC Cori)

```
&time_control
 run_days                  =  6,
 run_hours                 =  0,
 run_minutes               =  0,
 run_seconds               =  0,
 start_year                =  2012,  2012, 2012,
 start_month               =  06,    06,   06,
 start_day                 =  26,    26,   26,
 start_hour                =  00,    00,   00,
 start_minute              =  00,    00,   00,
 start_second              =  00,    00,   00,
 end_year                  =  2012,  2012, 2012,
 end_month                 =  07,    07,   07,
 end_day                   =  02,    02,   02,
 end_hour                  =  00,    00,   00,
 end_minute                =  00,    00,   00,
 end_second                =  00,    00,   00,
 interval_seconds          =  21600
 input_from_file           =  .true.,.true.,.true.,
 history_interval          =  60,  10, 10,
 frames_per_outfile        =  1,  1, 1,
 history_outname           =
"/global/cscratch1/sd/tshep/WRF_derecho/WRFV3/derecho4/files/wrfout/wrfout_d<domain>_<date>"
 restart                   =  .false.,
 restart_interval          =  1440,
 override_restart_timers   =  .true.,
 io_form_history           =  11
 io_form_restart           =  2
 io_form_input             =  2
 io_form_boundary          =  11
 io_form_auxinput2         =  11
 io_form_auxhist2          =  11
 debug_level               =  10
 nocolons                  =  .true.,
 auxinput4_inname          =  "wrflowinp_d<domain>",
 auxinput4_interval        =  1440,  1440,  1440,
 io_form_auxinput4         =  2,
 auxinput1_inname          =
"/global/cscratch1/sd/tshep/WPS_output/derecho/ERA5/met_em.d<domain>.<date>"
 iofields_filename         =  "my_file_d01.txt", "my_file_d02.txt", "my_file_d03.txt",
 ignore_iofields_warning   =  .true.,
 auxhist1_outname          =
"/global/cscratch1/sd/tshep/WRF_derecho/WRFV3/derecho4/files/wrfout/auxhist1_d<domain>_<date>"
 auxhist1_interval         =  60,  60,  60,
 frames_per_auxhist1       =  1,  1,  1,
 io_form_auxhist1          =  11,
```

Author's response to reviewer #1 and reviewer #2:

```
 output_diagnostics                 =  1,
 auxhist3_outname                   =
"/global/cscratch1/sd/tshep/WRF_derecho/WRFV3/derecho4/files/wrfout/wrfxtrm_d<domain>_<date>"
 auxhist3_interval                  = 60, 10, 10,
 frames_per_auxhist3                = 1, 1, 1,
 io_form_auxhist3                   = 11,
/
 &domains
 time_step                          = 30,
 time_step_fract_num                = 0,
 time_step_fract_den                = 1,
 max_dom                            = 3,
 e_we                               = 175,    262,   295,
 e_sn                               = 175,    262,   295,
 e_vert                             = 41,     41,    41,
 p_top_requested                    = 5000,
 sfcp_to_sfcp                       = .true.,
 num_metgrid_levels                 = 38,
 num_metgrid_soil_levels            = 4,
 dx                                 = 12000, 4000, 1333.33,
 dy                                 = 12000, 4000, 1333.33,
 grid_id                            = 1,     2,    3,
 parent_id                          = 1,     1,    2,
 i_parent_start                     = 1,     60,   105,
 j_parent_start                     = 1,     35,   75,
 parent_grid_ratio                  = 1,     3,    3,
 parent_time_step_ratio             = 1,     3,    3,
 feedback                           = 0,
 max_ts_locs                        = 0,
 eta_levels                         = 1.0000 , 0.9958 , 0.9916 , 0.9874 , 0.9832 ,
                                   0.9790 , 0.9749 , 0.9707 , 0.9661 , 0.9609 ,
                                   0.9549 , 0.9480 , 0.9398 , 0.9303 , 0.9189 ,
                                   0.9054 , 0.8894 , 0.8704 , 0.8481 , 0.8221 ,
                                   0.7922 , 0.7583 , 0.7205 , 0.6791 , 0.6346 ,
                                   0.5877 , 0.5393 , 0.4900 , 0.4407 , 0.3922 ,
                                   0.3450 , 0.2996 , 0.2564 , 0.2156 , 0.1773 ,
                                   0.1417 , 0.1086 , 0.0755 , 0.0475 , 0.0224 ,
                                   0.0000,
/
 &physics
 mp_physics                         = 10,    10,    10,     5,     5,
 ra_lw_physics                      = 1,     1,     1,     1,     1,
 ra_sw_physics                      = 1,     1,     1,     1,     1,
 radt                               = 10,    10,    10,    10,    10,
 sf_sfclay_physics                  = 1,     1,     1,     1,     1,
 sf_surface_physics                 = 2,     2,     2,     2,     2,
 bl_pbl_physics                     = 5,     5,     5,     5,     5,
```

Author's response to reviewer #1 and reviewer #2:

```
 bldt                                = 0,     0,     0,     0,     0,
 cu_physics                          = 1,     0,     0,     0,     0,
 cudt                                = 5,
 isfflx                              = 1,
 ifsnow                              = 1,
 icloud                              = 1,
 surface_input_source                = 3,
 num_soil_layers                     = 4,
 num_land_cat                        = 21,
 sf_urban_physics                    = 0,     0,     0,     0,     0,
 bl_mynn_tkebudget                   = 1,     1,     1,     1,     1,
 bl_mynn_tkeadvect                   = .true., .true., .true., .true., .true.,
 rdmaxalb                            = .false.,
 sst_update                          = 1,
 tmn_update                          = 1,
 usemonalb                           = .true.,
 lagday                              = 150,
 sst_skin                            = 1,
 slope_rad                           = 1,  1,  1,  1,  1,
 do_radar_ref                        = 1,
 prec_acc_dt                         = 60., 10., 10., 10., 10.,
 fractional_seaice                   = 1,
 seaice_threshold                    = 0.,
 /
 &noah_mp
 dveg                                = 4,
 opt_crs                             = 1,
 opt_btr                             = 2,
 opt_run                             = 3,
 opt_sfc                             = 1,
 opt_frz                             = 1,
 opt_inf                             = 1,
 opt_rad                             = 3,
 opt_alb                             = 2,
 opt_snf                             = 4,
 opt_tbot                            = 1,
opt_stc                              = 3,
/
 &dynamics
 w_damping                           = 1,
 diff_opt                            = 1,      1,      1,      1,      1,
 km_opt                              = 4,      4,      4,      4,      4,
 diff_6th_opt                        = 0,      0,      0,      0,      0,
 diff_6th_factor                     = 0.12,   0.12,   0.12,   0.12,   0.12,
 base_temp                           = 290.
 damp_opt                            = 0,
 zdamp                               = 5000.,  5000.,  5000.,  5000.,  5000.,
```

Author's response to reviewer #1 and reviewer #2:

```
dampcoef                = 0.01,   0.01,  0.01,   0.01,   0.01,
khdif                   = 0,      0,
kvdif                   = 0,      0,
non_hydrostatic         = .true., .true., .true., .true., .true.,
/
&bdy_control
spec_bdy_width          = 5,
spec_zone               = 1,
relax_zone              = 4,
spec_exp                = 0.13
specified               = .true., .false., .false., .false., .false.,
nested                  = .false., .true., .true.,  .true.,  .true.,
/
&grib2
/
&namelist_quilt
nio_tasks_per_group = 0,
nio_groups = 1,
/
```

Author's response to reviewer #1 and reviewer #2:

Morrison-intel+hail (Run on NERSC Cori)

```
&time_control
 run_days                            = 6,
 run_hours                           = 0,
 run_minutes                         = 0,
 run_seconds                         = 0,
 start_year                          = 2012, 2012, 2012,
 start_month                         = 06,   06,   06,
 start_day                           = 26,   26,   26,
 start_hour                          = 00,   00,   00,
 start_minute                        = 00,   00,   00,
 start_second                        = 00,   00,   00,
 end_year                            = 2012, 2012, 2012,
 end_month                           = 07,   07,   07,
 end_day                             = 02,   02,   02,
 end_hour                            = 00,   00,   00,
 end_minute                          = 00,   00,   00,
 end_second                          = 00,   00,   00,
 interval_seconds                    = 21600
 input_from_file                     = .true.,.true.,.true.,
 history_interval                    = 60,  10, 10,
 frames_per_outfile                  = 1,  1, 1,
 history_outname                     =
"/global/cscratch1/sd/tshep/WRF_derecho/WRFV3/derecho4/files/wrfout/wrfout_d<domain>_<date>"
 restart                             = .false.,
 restart_interval                    = 1440,
 override_restart_timers             = .true.,
 io_form_history                     = 11
 io_form_restart                     = 2
 io_form_input                       = 2
 io_form_boundary                    = 11
 io_form_auxinput2                   = 11
 io_form_auxhist2                    = 11
 debug_level                         = 10
 nocolons                            = .true.,
 auxinput4_inname                    = "wrflowinp_d<domain>",
 auxinput4_interval                  = 1440,  1440,  1440,
 io_form_auxinput4                   = 2,
 auxinput1_inname                    =
"/global/cscratch1/sd/tshep/WPS_output/derecho/ERA5/met_em.d<domain>.<date>"
 iofields_filename                   = "my_file_d01.txt", "my_file_d02.txt", "my_file_d03.txt",
 ignore_iofields_warning             = .true.,
 auxhist1_outname                    =
"/global/cscratch1/sd/tshep/WRF_derecho/WRFV3/derecho4/files/wrfout/auxhist1_d<domain>_<date>"
 auxhist1_interval                   = 60,  60,  60,
 frames_per_auxhist1                 = 1,  1,  1,
 io_form_auxhist1                    = 11,
```

```
 output_diagnostics                 =  1,
 auxhist3_outname                   =
"/global/cscratch1/sd/tshep/WRF_derecho/WRFV3/derecho4/files/wrfout/wrfxtrm_d<domain>_<date>"
 auxhist3_interval                  = 60, 10, 10,
 frames_per_auxhist3                = 1, 1, 1,
 io_form_auxhist3                   = 11,
/
 &domains
 time_step                          = 30,
 time_step_fract_num                = 0,
 time_step_fract_den                = 1,
 max_dom                            = 3,
 e_we                               = 175,    262,   295,
 e_sn                               = 175,    262,   295,
 e_vert                             = 41,     41,    41,
 p_top_requested                    = 5000,
 sfcp_to_sfcp                       = .true.,
 num_metgrid_levels                 = 38,
 num_metgrid_soil_levels            = 4,
 dx                                 = 12000, 4000, 1333.33,
 dy                                 = 12000, 4000, 1333.33,
 grid_id                            = 1,     2,    3,
 parent_id                          = 1,     1,    2,
 i_parent_start                     = 1,     60,   105,
 j_parent_start                     = 1,     35,   75,
 parent_grid_ratio                  = 1,     3,    3,
 parent_time_step_ratio             = 1,     3,    3,
 feedback                           = 0,
 max_ts_locs                        = 0,
 eta_levels                         = 1.0000 , 0.9958 , 0.9916 , 0.9874 , 0.9832 ,
                                      0.9790 , 0.9749 , 0.9707 , 0.9661 , 0.9609 ,
                                      0.9549 , 0.9480 , 0.9398 , 0.9303 , 0.9189 ,
                                      0.9054 , 0.8894 , 0.8704 , 0.8481 , 0.8221 ,
                                      0.7922 , 0.7583 , 0.7205 , 0.6791 , 0.6346 ,
                                      0.5877 , 0.5393 , 0.4900 , 0.4407 , 0.3922 ,
                                      0.3450 , 0.2996 , 0.2564 , 0.2156 , 0.1773 ,
                                      0.1417 , 0.1086 , 0.0755 , 0.0475 , 0.0224 ,
                                      0.0000,
/
 &physics
 mp_physics                         = 10,    10,    10,     5,     5,
 ra_lw_physics                      = 1,     1,     1,     1,     1,
 ra_sw_physics                      = 1,     1,     1,     1,     1,
 radt                               = 10,    10,    10,    10,    10,
 sf_sfclay_physics                  = 1,     1,     1,     1,     1,
 sf_surface_physics                 = 2,     2,     2,     2,     2,
 bl_pbl_physics                     = 5,     5,     5,     5,     5,
```

Author's response to reviewer #1 and reviewer #2:

```
bldt                         = 0,     0,     0,     0,     0,
cu_physics                   = 1,     0,     0,     0,     0,
cudt                         = 5,
isfflx                       = 1,
ifsnow                       = 1,
icloud                       = 1,
surface_input_source         = 3,
num_soil_layers              = 4,
num_land_cat                 = 21,
sf_urban_physics             = 0,     0,     0,     0,     0,
bl_mynn_tkebudget            = 1,     1,     1,     1,     1,
bl_mynn_tkeadvect            = .true., .true., .true., .true., .true.,
rdmaxalb                     = .false.,
sst_update                   = 1,
tmn_update                   = 1,
usemonalb                    = .true.,
lagday                       = 150,
sst_skin                     = 1,
slope_rad                    = 1,  1,  1,  1,  1,
do_radar_ref                 = 1,
prec_acc_dt                  = 60., 10., 10., 10., 10.,
fractional_seaice            = 1,
seaice_threshold             = 0.,
hail_opt                     = 1,
/
&noah_mp
dveg                         = 4,
opt_crs                      = 1,
opt_btr                      = 2,
opt_run                      = 3,
opt_sfc                      = 1,
opt_frz                      = 1,
opt_inf                      = 1,
opt_rad                      = 3,
opt_alb                      = 2,
opt_snf                      = 4,
opt_tbot                     = 1,
opt_stc                      = 3,
/
&dynamics
w_damping                    = 1,
diff_opt                     = 1,      1,      1,      1,      1,
km_opt                       = 4,      4,      4,      4,      4,
diff_6th_opt                 = 0,      0,      0,      0,      0,
diff_6th_factor              = 0.12,   0.12,   0.12,   0.12,   0.12,
base_temp                    = 290.
damp_opt                     = 0,
```

Author's response to reviewer #1 and reviewer #2:

```
zdamp                          = 5000.,  5000.,  5000.,  5000.,  5000.,
dampcoef                        = 0.01,    0.01,  0.01,   0.01,   0.01,
khdif                        = 0,      0,
kvdif                        = 0,      0,
non_hydrostatic                  = .true., .true., .true., .true., .true.,
/
&bdy_control
spec_bdy_width                   = 5,
spec_zone                       = 1,
relax_zone                      = 4,
spec_exp                        = 0.13
specified                      = .true., .false., .false., .false., .false.,
nested                        = .false., .true., .true.,  .true.,  .true.,
/
&grib2
/
&namelist_quilt
nio_tasks_per_group = 0,
nio_groups = 1,
/
```

Author's response to reviewer #1 and reviewer #2:

Milbrandt 26 June 00Z namelist

```
&time_control
 run_days                            = 6,
 run_hours                           = 0,
 run_minutes                         = 0,
 run_seconds                         = 0,
 start_year                          = 2012, 2012, 2012,
 start_month                         = 06,   06,   06,
 start_day                           = 26,   26,   26,
 start_hour                          = 00,   00,   00,
 start_minute                        = 00,   00,   00,
 start_second                        = 00,   00,   00,
 end_year                            = 2012, 2012, 2012,
 end_month                           = 07,   07,   07,
 end_day                             = 02,   02,   02,
 end_hour                            = 00,   00,   00,
 end_minute                          = 00,   00,   00,
 end_second                          = 00,   00,   00,
 interval_seconds                    = 21600
 input_from_file                     = .true.,.true.,.true.,
 history_interval                    = 60,  10, 10,
 frames_per_outfile                  = 1,  1, 1,
 history_outname                     =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfout_d<domain>_<date>"
 restart                             = .false.,
 restart_interval                    = 1440,
 override_restart_timers             = .true.,
 io_form_history                     = 11
 io_form_restart                     = 2
 io_form_input                       = 2
 io_form_boundary                    = 11
 io_form_auxinput2                   = 11
 io_form_auxhist2                    = 11
 debug_level                         = 10
 nocolons                            = .true.,
 auxinput4_inname                    = "wrflowinp_d<domain>",
 auxinput4_interval                  = 1440,  1440,  1440,
 io_form_auxinput4                   = 2,
 auxinput1_inname                    = "/data/derecho/met_files/ERA5/met_em.d<domain>.<date>"
 iofields_filename                   = "my_file_d01.txt", "my_file_d02.txt", "my_file_d03.txt",
 ignore_iofields_warning             = .true.,
 auxhist1_outname                    =
"/data/derecho/WRF_output/NE_2012/aux1/auxhist1_d<domain>_<date>"
 auxhist1_interval                   = 60,  60,  60,
 frames_per_auxhist1                 = 1,  1,  1,
 io_form_auxhist1                    = 11,
 output_diagnostics                  = 1,
```

Author's response to reviewer #1 and reviewer #2:

```
 auxhist3_outname                    =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfxtrm_d<domain>_<date>"
 auxhist3_interval                   = 60, 10, 10,
 frames_per_auxhist3                 = 1, 1, 1,
 io_form_auxhist3                    = 11,
/
 &domains
 time_step                           = 30,
 time_step_fract_num                 = 0,
 time_step_fract_den                 = 1,
 max_dom                             = 3,
 e_we                                = 175,    262,   295,
 e_sn                                = 175,    262,   295,
 e_vert                              = 41,     41,    41,
 p_top_requested                     = 5000,
 sfcp_to_sfcp                        = .true.,
 num_metgrid_levels                  = 38,
 num_metgrid_soil_levels             = 4,
 dx                                  = 12000, 4000, 1333.33,
 dy                                  = 12000, 4000, 1333.33,
 grid_id                             = 1,     2,    3,
 parent_id                           = 1,     1,    2,
 i_parent_start                      = 1,     60,   105,
 j_parent_start                      = 1,     35,   75,
 parent_grid_ratio                   = 1,     3,    3,
 parent_time_step_ratio              = 1,     3,    3,
 feedback                            = 0,
 max_ts_locs                         = 0,
 eta_levels                          = 1.0000 , 0.9958 , 0.9916 , 0.9874 , 0.9832 ,
                                       0.9790 , 0.9749 , 0.9707 , 0.9661 , 0.9609 ,
                                       0.9549 , 0.9480 , 0.9398 , 0.9303 , 0.9189 ,
                                       0.9054 , 0.8894 , 0.8704 , 0.8481 , 0.8221 ,
                                       0.7922 , 0.7583 , 0.7205 , 0.6791 , 0.6346 ,
                                       0.5877 , 0.5393 , 0.4900 , 0.4407 , 0.3922 ,
                                       0.3450 , 0.2996 , 0.2564 , 0.2156 , 0.1773 ,
                                       0.1417 , 0.1086 , 0.0755 , 0.0475 , 0.0224 ,
                                       0.0000,
/
 &physics
 mp_physics                          = 9,     9,     9,
 ra_lw_physics                       = 1,     1,     1,
 ra_sw_physics                       = 1,     1,     1,
 radt                                = 10,    10,    10,
 sf_sfclay_physics                   = 1,     1,     1,
 sf_surface_physics                  = 2,     2,     2,
 bl_pbl_physics                      = 5,     5,     5,
 bldt                                = 0,     0,     0,
```

Author's response to reviewer #1 and reviewer #2:

```
cu_physics                = 1,    0,    0,
cudt                      = 5,
isfflx                    = 1,
ifsnow                    = 1,
icloud                    = 1,
surface_input_source      = 3,
num_soil_layers           = 4,
num_land_cat              = 21,
sf_urban_physics          = 0,    0,    0,
bl_mynn_tkebudget         = 1,    1,    1,
bl_mynn_tkeadvect         = .true., .true., .true.,
rdmaxalb                  = .false.,
sst_update                = 1,
tmn_update                = 1,
usemonalb                 = .true.,
lagday                    = 150,
sst_skin                  = 1,
slope_rad                 = 1,  1,  1,
prec_acc_dt               = 60., 10., 10.,
fractional_seaice         = 1,
seaice_threshold          = 0.,
/
&noah_mp
dveg                      = 4,
opt_crs                   = 1,
opt_btr                   = 2,
opt_run                   = 3,
opt_sfc                   = 1,
opt_frz                   = 1,
opt_inf                   = 1,
opt_rad                   = 3,
opt_alb                   = 2,
opt_snf                   = 4,
opt_tbot                  = 1,
opt_stc                   = 3,
/
&dynamics
w_damping                 = 1,
diff_opt                  = 1,    1,    1,
km_opt                    = 4,    4,    4,
diff_6th_opt              = 0,    0,    0,
diff_6th_factor           = 0.12,   0.12,   0.12,
base_temp                 = 290.
damp_opt                  = 0,
zdamp                     = 5000.,  5000.,  5000.,
dampcoef                  = 0.01,   0.01,  0.01,
khdif                     = 0,    0,
```

Author's response to reviewer #1 and reviewer #2:

```
kvdif                    = 0,      0,
non_hydrostatic          = .true., .true., .true.,
/
&bdy_control
spec_bdy_width           = 5,
spec_zone                = 1,
relax_zone               = 4,
spec_exp                 = 0.13
specified                = .true., .false., .false.,
nested                   = .false., .true., .true.,
/
&grib2
/
&namelist_quilt
nio_tasks_per_group = 0,
nio_groups = 1,
/
```

Author's response to reviewer #1 and reviewer #2:

Milbrandt 28 June 00Z namelist

```
&time_control
 run_days                            = 4,
 run_hours                           = 0,
 run_minutes                         = 0,
 run_seconds                         = 0,
 start_year                          = 2012,  2012, 2012,
 start_month                         = 06,    06,   06,
 start_day                           = 28,    28,   28,
 start_hour                          = 00,    00,   00,
 start_minute                        = 00,    00,   00,
 start_second                        = 00,    00,   00,
 end_year                            = 2012,  2012, 2012,
 end_month                           = 07,    07,   07,
 end_day                             = 02,    02,   02,
 end_hour                            = 00,    00,   00,
 end_minute                          = 00,    00,   00,
 end_second                          = 00,    00,   00,
 interval_seconds                    = 21600
 input_from_file                     = .true.,.true.,.true.,
 history_interval                    = 60,  10, 10,
 frames_per_outfile                  = 1,  1, 1,
 history_outname                     =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfout_d<domain>_<date>"
 restart                             = .false.,
 restart_interval                    = 1440,
 override_restart_timers             = .true.,
 io_form_history                     = 11
 io_form_restart                     = 2
 io_form_input                       = 2
 io_form_boundary                    = 11
 io_form_auxinput2                   = 11
 io_form_auxhist2                    = 11
 debug_level                         = 10
 nocolons                            = .true.,
 auxinput4_inname                    = "wrflowinp_d<domain>",
 auxinput4_interval                  = 1440,  1440,  1440,
 io_form_auxinput4                   = 2,
 auxinput1_inname                    = "/data/derecho/met_files/ERA5/met_em.d<domain>.<date>"
 iofields_filename                   = "my_file_d01.txt", "my_file_d02.txt", "my_file_d03.txt",
 ignore_iofields_warning             = .true.,
 auxhist1_outname                    =
"/data/derecho/WRF_output/NE_2012/aux1/auxhist1_d<domain>_<date>"
 auxhist1_interval                   = 60,  60,  60,
 frames_per_auxhist1                 = 1,  1,  1,
 io_form_auxhist1                    = 11,
 output_diagnostics                  = 1,
```

```
 auxhist3_outname                    =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfxtrm_d<domain>_<date>"
 auxhist3_interval                   = 60, 10, 10,
 frames_per_auxhist3                 = 1, 1, 1,
 io_form_auxhist3                    = 11,
/
 &domains
 time_step                           = 30,
 time_step_fract_num                 = 0,
 time_step_fract_den                 = 1,
 max_dom                             = 3,
 e_we                                = 175,    262,   295,
 e_sn                                = 175,    262,   295,
 e_vert                              = 41,     41,    41,
 p_top_requested                     = 5000,
 sfcp_to_sfcp                        = .true.,
 num_metgrid_levels                  = 38,
 num_metgrid_soil_levels             = 4,
 dx                                  = 12000, 4000, 1333.33,
 dy                                  = 12000, 4000, 1333.33,
 grid_id                             = 1,     2,    3,
 parent_id                           = 1,     1,    2,
 i_parent_start                      = 1,     60,   105,
 j_parent_start                      = 1,     35,   75,
 parent_grid_ratio                   = 1,     3,    3,
 parent_time_step_ratio              = 1,     3,    3,
 feedback                            = 0,
 max_ts_locs                         = 0,
 eta_levels                          = 1.0000 , 0.9958 , 0.9916 , 0.9874 , 0.9832 ,
                                     0.9790 , 0.9749 , 0.9707 , 0.9661 , 0.9609 ,
                                     0.9549 , 0.9480 , 0.9398 , 0.9303 , 0.9189 ,
                                     0.9054 , 0.8894 , 0.8704 , 0.8481 , 0.8221 ,
                                     0.7922 , 0.7583 , 0.7205 , 0.6791 , 0.6346 ,
                                     0.5877 , 0.5393 , 0.4900 , 0.4407 , 0.3922 ,
                                     0.3450 , 0.2996 , 0.2564 , 0.2156 , 0.1773 ,
                                     0.1417 , 0.1086 , 0.0755 , 0.0475 , 0.0224 ,
                                     0.0000,
/
 &physics
 mp_physics                          = 9,     9,     9,
 ra_lw_physics                       = 1,     1,     1,
 ra_sw_physics                       = 1,     1,     1,
 radt                                = 10,    10,    10,
 sf_sfclay_physics                   = 1,     1,     1,
 sf_surface_physics                  = 2,     2,     2,
 bl_pbl_physics                      = 5,     5,     5,
 bldt                                = 0,     0,     0,
```

Author's response to reviewer #1 and reviewer #2:

```
cu_physics                    = 1,     0,     0,
cudt                          = 5,
isfflx                        = 1,
ifsnow                        = 1,
icloud                        = 1,
surface_input_source          = 3,
num_soil_layers               = 4,
num_land_cat                  = 21,
sf_urban_physics              = 0,     0,     0,
bl_mynn_tkebudget             = 1,     1,     1,
bl_mynn_tkeadvect             = .true., .true., .true.,
rdmaxalb                      = .false.,
sst_update                    = 1,
tmn_update                    = 1,
usemonalb                     = .true.,
lagday                        = 150,
sst_skin                      = 1,
slope_rad                     = 1,  1,  1,
prec_acc_dt                   = 60., 10., 10.,
fractional_seaice             = 1,
seaice_threshold              = 0.,
/
&noah_mp
dveg                          = 4,
opt_crs                       = 1,
opt_btr                       = 2,
opt_run                       = 3,
opt_sfc                       = 1,
opt_frz                       = 1,
opt_inf                       = 1,
opt_rad                       = 3,
opt_alb                       = 2,
opt_snf                       = 4,
opt_tbot                      = 1,
opt_stc                       = 3,
/
&dynamics
w_damping                     = 1,
diff_opt                      = 1,      1,      1,
km_opt                        = 4,      4,      4,
diff_6th_opt                  = 0,      0,      0,
diff_6th_factor               = 0.12,   0.12,   0.12,
base_temp                     = 290.
damp_opt                      = 0,
zdamp                         = 5000.,  5000.,  5000.,
dampcoef                      = 0.01,   0.01,  0.01,
khdif                         = 0,      0,
```

```
kvdif                          = 0,      0,
non_hydrostatic                     = .true., .true., .true.,
/
&bdy_control
spec_bdy_width                      = 5,
spec_zone                           = 1,
relax_zone                          = 4,
spec_exp                            = 0.13
specified                           = .true., .false., .false.,
nested                              = .false., .true., .true.,
/
&grib2
/
&namelist_quilt
nio_tasks_per_group = 0,
nio_groups = 1,
/
```

Author’s response to reviewer #1 and reviewer #2:

NSSL namelist

```
&time_control
 run_days                  = 6,
 run_hours                 = 0,
 run_minutes               = 0,
 run_seconds               = 0,
 start_year                = 2012, 2012, 2012,
 start_month               = 06,   06,   06,
 start_day                 = 26,   26,   26,
 start_hour                = 00,   00,   00,
 start_minute              = 00,   00,   00,
 start_second              = 00,   00,   00,
 end_year                  = 2012, 2012, 2012,
 end_month                 = 07,   07,   07,
 end_day                   = 02,   02,   02,
 end_hour                  = 00,   00,   00,
 end_minute                = 00,   00,   00,
 end_second                = 00,   00,   00,
 interval_seconds          = 21600
 input_from_file           = .true.,.true.,.true.,
 history_interval          = 60, 10, 10,
 frames_per_outfile        = 1, 1, 1,
 history_outname           =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfout_d<domain>_<date>"
 restart                   = .false.,
 restart_interval          = 1440,
 override_restart_timers   = .true.,
 io_form_history           = 11
 io_form_restart           = 2
 io_form_input             = 2
 io_form_boundary          = 11
 io_form_auxinput2         = 11
 io_form_auxhist2          = 11
 debug_level               = 10
 nocolons                  = .true.,
 auxinput4_inname          = "wrflowinp_d<domain>",
 auxinput4_interval        = 1440, 1440, 1440,
 io_form_auxinput4         = 2,
 auxinput1_inname          = "/data/derecho/met_files/ERA5/met_em.d<domain>.<date>"
 iofields_filename         = "my_file_d01.txt", "my_file_d02.txt", "my_file_d03.txt",
 ignore_iofields_warning   = .true.,
 auxhist1_outname          =
"/data/derecho/WRF_output/NE_2012/aux1/auxhist1_d<domain>_<date>"
 auxhist1_interval         = 60, 60, 60,
 frames_per_auxhist1       = 1, 1, 1,
 io_form_auxhist1          = 11,
```

Author's response to reviewer #1 and reviewer #2:

```
 output_diagnostics                  =  1,
 auxhist3_outname                    =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfxtrm_d<domain>_<date>"
 auxhist3_interval                   = 60, 10, 10,
 frames_per_auxhist3                 = 1, 1, 1,
 io_form_auxhist3                    = 11,
/
 &domains
 time_step                           = 30,
 time_step_fract_num                 = 0,
 time_step_fract_den                 = 1,
 max_dom                             = 3,
 e_we                                = 175,    262,   295,
 e_sn                                = 175,    262,   295,
 e_vert                              = 41,     41,    41,
 p_top_requested                     = 5000,
 sfcp_to_sfcp                        = .true.,
 num_metgrid_levels                  = 38,
 num_metgrid_soil_levels             = 4,
 dx                                  = 12000, 4000, 1333.33,
 dy                                  = 12000, 4000, 1333.33,
 grid_id                             = 1,     2,    3,
 parent_id                           = 1,     1,    2,
 i_parent_start                      = 1,     60,   105,
 j_parent_start                      = 1,     35,   75,
 parent_grid_ratio                   = 1,     3,    3,
 parent_time_step_ratio              = 1,     3,    3,
 feedback                            = 0,
 max_ts_locs                         = 0,
 eta_levels                          = 1.0000 , 0.9958 , 0.9916 , 0.9874 , 0.9832 ,
                                     0.9790 , 0.9749 , 0.9707 , 0.9661 , 0.9609 ,
                                     0.9549 , 0.9480 , 0.9398 , 0.9303 , 0.9189 ,
                                     0.9054 , 0.8894 , 0.8704 , 0.8481 , 0.8221 ,
                                     0.7922 , 0.7583 , 0.7205 , 0.6791 , 0.6346 ,
                                     0.5877 , 0.5393 , 0.4900 , 0.4407 , 0.3922 ,
                                     0.3450 , 0.2996 , 0.2564 , 0.2156 , 0.1773 ,
                                     0.1417 , 0.1086 , 0.0755 , 0.0475 , 0.0224 ,
                                     0.0000,
/
 &physics
 mp_physics                          = 17,    17,    17,
 ra_lw_physics                       = 1,     1,     1,
 ra_sw_physics                       = 1,     1,     1,
 radt                                = 10,    10,    10,
 sf_sfclay_physics                   = 1,     1,     1,
 sf_surface_physics                  = 2,     2,     2,
 bl_pbl_physics                      = 5,     5,     5,
```

Author's response to reviewer #1 and reviewer #2:

```
bldt                       = 0,     0,     0,
cu_physics                 = 1,     0,     0,
cudt                       = 5,
isfflx                     = 1,
ifsnow                     = 1,
icloud                     = 1,
surface_input_source       = 3,
num_soil_layers            = 4,
num_land_cat               = 21,
sf_urban_physics           = 0,     0,     0,
bl_mynn_tkebudget          = 1,     1,     1,
bl_mynn_tkeadvect          = .true., .true., .true.,
rdmaxalb                   = .false.,
sst_update                 = 1,
tmn_update                 = 1,
usemonalb                  = .true.,
lagday                     = 150,
sst_skin                   = 1,
slope_rad                  = 1,  1,  1,
prec_acc_dt                = 60., 10., 10.,
fractional_seaice          = 1,
seaice_threshold           = 0.,
/
&noah_mp
dveg                       = 4,
opt_crs                    = 1,
opt_btr                    = 2,
opt_run                    = 3,
opt_sfc                    = 1,
opt_frz                    = 1,
opt_inf                    = 1,
opt_rad                    = 3,
opt_alb                    = 2,
opt_snf                    = 4,
opt_tbot                   = 1,
opt_stc                    = 3,
/
&dynamics
w_damping                  = 1,
diff_opt                   = 1,      1,      1,
km_opt                     = 4,      4,      4,
diff_6th_opt               = 0,      0,      0,
diff_6th_factor            = 0.12,   0.12,   0.12,
base_temp                  = 290.
damp_opt                   = 0,
zdamp                      = 5000.,  5000.,  5000.,
dampcoef                   = 0.01,    0.01,  0.01,
```

Author's response to reviewer #1 and reviewer #2:

```
khdif                    = 0,      0,
kvdif                    = 0,      0,
non_hydrostatic                    = .true., .true., .true.,
/
&bdy_control
spec_bdy_width                     = 5,
spec_zone                      = 1,
relax_zone                     = 4,
spec_exp                       = 0.13
specified                     = .true., .false., .false.,
nested                        = .false., .true., .true.,
/
&grib2
/
&namelist_quilt
nio_tasks_per_group = 0,
nio_groups = 1,
/
```

Author's response to reviewer #1 and reviewer #2:

Thompson namelist

```
&time_control
 run_days                            = 6,
 run_hours                           = 0,
 run_minutes                         = 0,
 run_seconds                         = 0,
 start_year                          = 2012, 2012, 2012,
 start_month                         = 06,   06,   06,
 start_day                           = 26,   26,   26,
 start_hour                          = 00,   00,   00,
 start_minute                        = 00,   00,   00,
 start_second                        = 00,   00,   00,
 end_year                            = 2012, 2012, 2012,
 end_month                           = 07,   07,   07,
 end_day                             = 02,   02,   02,
 end_hour                            = 00,   00,   00,
 end_minute                          = 00,   00,   00,
 end_second                          = 00,   00,   00,
 interval_seconds                    = 21600
 input_from_file                     = .true.,.true.,.true.,
 history_interval                    = 60, 10, 10,
 frames_per_outfile                  = 1, 1, 1,
 history_outname                     =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfout_d<domain>_<date>"
 restart                             = .false.,
 restart_interval                    = 1440,
 override_restart_timers             = .true.,
 io_form_history                     = 11
 io_form_restart                     = 2
 io_form_input                       = 2
 io_form_boundary                    = 11
 io_form_auxinput2                   = 11
 io_form_auxhist2                    = 11
 debug_level                         = 10
 nocolons                            = .true.,
 auxinput4_inname                    = "wrflowinp_d<domain>",
 auxinput4_interval                  = 1440, 1440, 1440,
 io_form_auxinput4                   = 2,
 auxinput1_inname                    = "/data/derecho/met_files/ERA5/met_em.d<domain>.<date>"
 iofields_filename                   = "my_file_d01.txt", "my_file_d02.txt", "my_file_d03.txt",
 ignore_iofields_warning             = .true.,
 auxhist1_outname                    =
"/data/derecho/WRF_output/NE_2012/aux1/auxhist1_d<domain>_<date>"
 auxhist1_interval                   = 60, 60, 60,
 frames_per_auxhist1                 = 1, 1, 1,
 io_form_auxhist1                    = 11,
 output_diagnostics                  = 1,
```

```
 auxhist3_outname                    =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfxtrm_d<domain>_<date>"
 auxhist3_interval                   = 60, 10, 10,
 frames_per_auxhist3                 = 1, 1, 1,
 io_form_auxhist3                    = 11,
/
 &domains
 time_step                           = 30,
 time_step_fract_num                 = 0,
 time_step_fract_den                 = 1,
 max_dom                             = 3,
 e_we                                = 175,    262,   295,
 e_sn                                = 175,    262,   295,
 e_vert                              = 41,     41,    41,
 p_top_requested                     = 5000,
 sfcp_to_sfcp                        = .true.,
 num_metgrid_levels                  = 38,
 num_metgrid_soil_levels             = 4,
 dx                                  = 12000, 4000, 1333.33,
 dy                                  = 12000, 4000, 1333.33,
 grid_id                             = 1,     2,    3,
 parent_id                           = 1,     1,    2,
 i_parent_start                      = 1,     60,   105,
 j_parent_start                      = 1,     35,   75,
 parent_grid_ratio                   = 1,     3,    3,
 parent_time_step_ratio              = 1,     3,    3,
 feedback                            = 0,
 max_ts_locs                         = 0,
 eta_levels                          = 1.0000 , 0.9958 , 0.9916 , 0.9874 , 0.9832 ,
                                       0.9790 , 0.9749 , 0.9707 , 0.9661 , 0.9609 ,
                                       0.9549 , 0.9480 , 0.9398 , 0.9303 , 0.9189 ,
                                       0.9054 , 0.8894 , 0.8704 , 0.8481 , 0.8221 ,
                                       0.7922 , 0.7583 , 0.7205 , 0.6791 , 0.6346 ,
                                       0.5877 , 0.5393 , 0.4900 , 0.4407 , 0.3922 ,
                                       0.3450 , 0.2996 , 0.2564 , 0.2156 , 0.1773 ,
                                       0.1417 , 0.1086 , 0.0755 , 0.0475 , 0.0224 ,
                                       0.0000,
/
 &physics
 mp_physics                          = 8,     8,     8,
 ra_lw_physics                       = 1,     1,     1,
 ra_sw_physics                       = 1,     1,     1,
 radt                                = 10,    10,    10,
 sf_sfclay_physics                   = 1,     1,     1,
 sf_surface_physics                  = 2,     2,     2,
 bl_pbl_physics                      = 5,     5,     5,
 bldt                                = 0,     0,     0,
```

Author's response to reviewer #1 and reviewer #2:

```
cu_physics                 = 1,     0,     0,
cudt                       = 5,
isfflx                     = 1,
ifsnow                     = 1,
icloud                     = 1,
surface_input_source       = 3,
num_soil_layers            = 4,
num_land_cat               = 21,
sf_urban_physics           = 0,     0,     0,
bl_mynn_tkebudget          = 1,     1,     1,
bl_mynn_tkeadvect          = .true., .true., .true.,
rdmaxalb                   = .false.,
sst_update                 = 1,
tmn_update                 = 1,
usemonalb                  = .true.,
lagday                     = 150,
sst_skin                   = 1,
slope_rad                  = 1,  1,  1,
prec_acc_dt                = 60., 10., 10.,
do_radar_ref               = 1,
fractional_seaice          = 1,
seaice_threshold           = 0.,
/
&noah_mp
dveg                       = 4,
opt_crs                    = 1,
opt_btr                    = 2,
opt_run                    = 3,
opt_sfc                    = 1,
opt_frz                    = 1,
opt_inf                    = 1,
opt_rad                    = 3,
opt_alb                    = 2,
opt_snf                    = 4,
opt_tbot                   = 1,
opt_stc                    = 3,
/
&dynamics
w_damping                  = 1,
diff_opt                   = 1,      1,      1,
km_opt                     = 4,      4,      4,
diff_6th_opt               = 0,      0,      0,
diff_6th_factor            = 0.12,   0.12,   0.12,
base_temp                  = 290.
damp_opt                   = 0,
zdamp                      = 5000.,  5000.,  5000.,
dampcoef                   = 0.01,    0.01,  0.01,
```

Author's response to reviewer #1 and reviewer #2:

```
khdif                    = 0,     0,
kvdif                    = 0,     0,
non_hydrostatic          = .true., .true., .true.,
/
&bdy_control
spec_bdy_width           = 5,
spec_zone                = 1,
relax_zone               = 4,
spec_exp                 = 0.13
specified                = .true., .false., .false.,
nested                   = .false., .true., .true.,
/
&grib2
/
&namelist_quilt
nio_tasks_per_group = 0,
nio_groups = 1,
/
```

Author's response to reviewer #1 and reviewer #2:

Goddard namelist

```
&time_control
 run_days                            = 6,
 run_hours                           = 0,
 run_minutes                         = 0,
 run_seconds                         = 0,
 start_year                          = 2012, 2012, 2012,
 start_month                         = 06,   06,   06,
 start_day                           = 26,   26,   26,
 start_hour                          = 00,   00,   00,
 start_minute                        = 00,   00,   00,
 start_second                        = 00,   00,   00,
 end_year                            = 2012, 2012, 2012,
 end_month                           = 07,   07,   07,
 end_day                             = 02,   02,   02,
 end_hour                            = 00,   00,   00,
 end_minute                          = 00,   00,   00,
 end_second                          = 00,   00,   00,
 interval_seconds                    = 21600
 input_from_file                     = .true.,.true.,.true.,
 history_interval                    = 60, 10, 10,
 frames_per_outfile                  = 1, 1, 1,
 history_outname                     =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfout_d<domain>_<date>"
 restart                             = .false.,
 restart_interval                    = 1440,
 override_restart_timers             = .true.,
 io_form_history                     = 11
 io_form_restart                     = 2
 io_form_input                       = 2
 io_form_boundary                    = 11
 io_form_auxinput2                   = 11
 io_form_auxhist2                    = 11
 debug_level                         = 10
 nocolons                            = .true.,
 auxinput4_inname                    = "wrflowinp_d<domain>",
 auxinput4_interval                  = 1440, 1440, 1440,
 io_form_auxinput4                   = 2,
 auxinput1_inname                    = "/data/derecho/met_files/ERA5/met_em.d<domain>.<date>"
 iofields_filename                   = "my_file_d01.txt", "my_file_d02.txt", "my_file_d03.txt",
 ignore_iofields_warning             = .true.,
 auxhist1_outname                    =
"/data/derecho/WRF_output/NE_2012/aux1/auxhist1_d<domain>_<date>"
 auxhist1_interval                   = 60, 60, 60,
 frames_per_auxhist1                 = 1, 1, 1,
 io_form_auxhist1                    = 11,
 output_diagnostics                  = 1,
```

Author's response to reviewer #1 and reviewer #2:

```
 auxhist3_outname                    =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfxtrm_d<domain>_<date>"
 auxhist3_interval                   = 60, 10, 10,
 frames_per_auxhist3                 = 1, 1, 1,
 io_form_auxhist3                    = 11,
/
 &domains
 time_step                           = 30,
 time_step_fract_num                 = 0,
 time_step_fract_den                 = 1,
 max_dom                             = 3,
 e_we                                = 175,    262,   295,
 e_sn                                = 175,    262,   295,
 e_vert                              = 41,     41,    41,
 p_top_requested                     = 5000,
 sfcp_to_sfcp                        = .true.,
 num_metgrid_levels                  = 38,
 num_metgrid_soil_levels             = 4,
 dx                                  = 12000, 4000, 1333.33,
 dy                                  = 12000, 4000, 1333.33,
 grid_id                             = 1,     2,    3,
 parent_id                           = 1,     1,    2,
 i_parent_start                      = 1,     60,   105,
 j_parent_start                      = 1,     35,   75,
 parent_grid_ratio                   = 1,     3,    3,
 parent_time_step_ratio              = 1,     3,    3,
 feedback                            = 0,
 max_ts_locs                         = 0,
 eta_levels                          = 1.0000 , 0.9958 , 0.9916 , 0.9874 , 0.9832 ,
                                     0.9790 , 0.9749 , 0.9707 , 0.9661 , 0.9609 ,
                                     0.9549 , 0.9480 , 0.9398 , 0.9303 , 0.9189 ,
                                     0.9054 , 0.8894 , 0.8704 , 0.8481 , 0.8221 ,
                                     0.7922 , 0.7583 , 0.7205 , 0.6791 , 0.6346 ,
                                     0.5877 , 0.5393 , 0.4900 , 0.4407 , 0.3922 ,
                                     0.3450 , 0.2996 , 0.2564 , 0.2156 , 0.1773 ,
                                     0.1417 , 0.1086 , 0.0755 , 0.0475 , 0.0224 ,
                                     0.0000,
/
 &physics
 mp_physics                          = 7,     7,     7,
 gsfcgce_hail                        = 1,
 ra_lw_physics                       = 1,     1,     1,
 ra_sw_physics                       = 1,     1,     1,
 radt                                = 10,    10,    10,
 sf_sfclay_physics                   = 1,     1,     1,
 sf_surface_physics                  = 2,     2,     2,
 bl_pbl_physics                      = 5,     5,     5,
```

Author's response to reviewer #1 and reviewer #2:

```
bldt                   = 0,    0,    0,
cu_physics                = 1,    0,    0,
cudt                   = 5,
isfflx                 = 1,
ifsnow                   = 1,
icloud                  = 1,
surface_input_source           = 3,
num_soil_layers             = 4,
num_land_cat               = 21,
sf_urban_physics             = 0,    0,    0,
bl_mynn_tkebudget             = 1,    1,    1,
bl_mynn_tkeadvect             = .true., .true., .true.,
rdmaxalb                 = .false.,
sst_update                = 1,
tmn_update                 = 1,
usemonalb                 = .true.,
lagday                  = 150,
sst_skin                  = 1,
slope_rad                 = 1,  1,  1,
prec_acc_dt                = 60., 10., 10.,
do_radar_ref               = 1,
fractional_seaice              = 1,
seaice_threshold              = 0.,
/
&noah_mp
dveg                   = 4,
opt_crs                  = 1,
opt_btr                  = 2,
opt_run                  = 3,
opt_sfc                  = 1,
opt_frz                  = 1,
opt_inf                  = 1,
opt_rad                  = 3,
opt_alb                  = 2,
opt_snf                  = 4,
opt_tbot                  = 1,
opt_stc                  = 3,
/
&dynamics
w_damping                 = 1,
diff_opt                 = 1,     1,     1,
km_opt                  = 4,     4,     4,
diff_6th_opt               = 0,     0,     0,
diff_6th_factor              = 0.12,   0.12,   0.12,
base_temp                 = 290.
damp_opt                  = 0,
zdamp                   = 5000.,  5000.,  5000.,
```

Author's response to reviewer #1 and reviewer #2:

```
dampcoef                   = 0.01,    0.01,  0.01,
khdif                      = 0,      0,
kvdif                      = 0,      0,
non_hydrostatic            = .true., .true., .true.,
/
&bdy_control
spec_bdy_width             = 5,
spec_zone                  = 1,
relax_zone                 = 4,
spec_exp                   = 0.13
specified                  = .true., .false., .false.,
nested                     = .false., .true., .true.,
/
&grib2
/
&namelist_quilt
nio_tasks_per_group = 0,
nio_groups = 1,
/
```

Milbrandt 26 June 00Z ERA-I namelist

```
&time_control
 run_days                            = 6,
 run_hours                           = 0,
 run_minutes                         = 0,
 run_seconds                         = 0,
 start_year                          = 2012, 2012, 2012,
 start_month                         = 06,   06,   06,
 start_day                           = 26,   26,   26,
 start_hour                          = 00,   00,   00,
 start_minute                        = 00,   00,   00,
 start_second                        = 00,   00,   00,
 end_year                            = 2012, 2012, 2012,
 end_month                           = 07,   07,   07,
 end_day                             = 02,   02,   02,
 end_hour                            = 00,   00,   00,
 end_minute                          = 00,   00,   00,
 end_second                          = 00,   00,   00,
 interval_seconds                    = 21600
 input_from_file                     = .true.,.true.,.true.,
 history_interval                    = 60, 10, 10,
 frames_per_outfile                  = 1, 1, 1,
 history_outname                     =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfout_d<domain>_<date>"
 restart                             = .false.,
 restart_interval                    = 1440,
 override_restart_timers             = .true.,
 io_form_history                     = 11
 io_form_restart                     = 2
 io_form_input                       = 2
 io_form_boundary                    = 11
 io_form_auxinput2                   = 11
 io_form_auxhist2                    = 11
 debug_level                         = 10
 nocolons                            = .true.,
 auxinput4_inname                    = "wrflowinp_d<domain>",
 auxinput4_interval                  = 1440, 1440, 1440,
 io_form_auxinput4                   = 2,
 auxinput1_inname                    = "/data/derecho/met_files/ERA-I/met_em.d<domain>.<date>"
 iofields_filename                   = "my_file_d01.txt", "my_file_d02.txt", "my_file_d03.txt",
 ignore_iofields_warning             = .true.,
 auxhist1_outname                    =
"/data/derecho/WRF_output/NE_2012/aux1/auxhist1_d<domain>_<date>"
 auxhist1_interval                   = 60, 60, 60,
 frames_per_auxhist1                 = 1, 1, 1,
 io_form_auxhist1                    = 11,
```

```
 output_diagnostics                  =  1,
 auxhist3_outname                    =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfxtrm_d<domain>_<date>"
 auxhist3_interval                   = 60, 10, 10,
 frames_per_auxhist3                 = 1, 1, 1,
 io_form_auxhist3                    = 11,
/
 &domains
 time_step                           = 30,
 time_step_fract_num                 = 0,
 time_step_fract_den                 = 1,
 max_dom                             = 3,
 e_we                                = 175,    262,   295,
 e_sn                                = 175,    262,   295,
 e_vert                              = 41,     41,    41,
 p_top_requested                     = 5000,
 sfcp_to_sfcp                        = .true.,
 num_metgrid_levels                  = 61,
 num_metgrid_soil_levels             = 4,
 dx                                  = 12000, 4000, 1333.33,
 dy                                  = 12000, 4000, 1333.33,
 grid_id                             = 1,     2,    3,
 parent_id                           = 1,     1,    2,
 i_parent_start                      = 1,     60,   105,
 j_parent_start                      = 1,     35,   75,
 parent_grid_ratio                   = 1,     3,    3,
 parent_time_step_ratio              = 1,     3,    3,
 feedback                            = 0,
 max_ts_locs                         = 0,
 eta_levels                          = 1.0000 , 0.9958 , 0.9916 , 0.9874 , 0.9832 ,
                                     0.9790 , 0.9749 , 0.9707 , 0.9661 , 0.9609 ,
                                     0.9549 , 0.9480 , 0.9398 , 0.9303 , 0.9189 ,
                                     0.9054 , 0.8894 , 0.8704 , 0.8481 , 0.8221 ,
                                     0.7922 , 0.7583 , 0.7205 , 0.6791 , 0.6346 ,
                                     0.5877 , 0.5393 , 0.4900 , 0.4407 , 0.3922 ,
                                     0.3450 , 0.2996 , 0.2564 , 0.2156 , 0.1773 ,
                                     0.1417 , 0.1086 , 0.0755 , 0.0475 , 0.0224 ,
                                     0.0000,
/
 &physics
 mp_physics                          = 9,     9,     9,
 ra_lw_physics                       = 1,     1,     1,
 ra_sw_physics                       = 1,     1,     1,
 radt                                = 10,    10,    10,
 sf_sfclay_physics                   = 1,     1,     1,
 sf_surface_physics                  = 2,     2,     2,
 bl_pbl_physics                      = 5,     5,     5,
```

Author's response to reviewer #1 and reviewer #2:

```
bldt                     = 0,     0,     0,
cu_physics               = 1,     0,     0,
cudt                     = 5,
isfflx                   = 1,
ifsnow                   = 1,
icloud                   = 1,
surface_input_source     = 3,
num_soil_layers          = 4,
num_land_cat             = 21,
sf_urban_physics         = 0,     0,     0,
bl_mynn_tkebudget        = 1,     1,     1,
bl_mynn_tkeadvect        = .true., .true., .true.,
rdmaxalb                 = .false.,
sst_update               = 1,
tmn_update               = 1,
usemonalb                = .true.,
lagday                   = 150,
sst_skin                 = 1,
slope_rad                = 1,  1,  1,
prec_acc_dt              = 60., 10., 10.,
fractional_seaice        = 1,
seaice_threshold         = 0.,
/
&noah_mp
dveg                     = 4,
opt_crs                  = 1,
opt_btr                  = 2,
opt_run                  = 3,
opt_sfc                  = 1,
opt_frz                  = 1,
opt_inf                  = 1,
opt_rad                  = 3,
opt_alb                  = 2,
opt_snf                  = 4,
opt_tbot                 = 1,
opt_stc                  = 3,
/
&dynamics
w_damping                = 1,
diff_opt                 = 1,      1,      1,
km_opt                   = 4,      4,      4,
diff_6th_opt             = 0,      0,      0,
diff_6th_factor          = 0.12,   0.12,   0.12,
base_temp                = 290.
damp_opt                 = 0,
zdamp                    = 5000.,  5000.,  5000.,
dampcoef                 = 0.01,   0.01,  0.01,
```

Author's response to reviewer #1 and reviewer #2:

```
khdif                    = 0,      0,
kvdif                    = 0,      0,
non_hydrostatic               = .true., .true., .true.,
/
&bdy_control
spec_bdy_width                = 5,
spec_zone                   = 1,
relax_zone                  = 4,
spec_exp                   = 0.13
specified                  = .true., .false., .false.,
nested                    = .false., .true., .true.,
/
&grib2
/
&namelist_quilt
nio_tasks_per_group = 0,
nio_groups = 1,
/
```

Milbrant 28 June 00Z ERA-I namelist

```
&time_control
 run_days                    = 4,
 run_hours                   = 0,
 run_minutes                 = 0,
 run_seconds                 = 0,
 start_year                  = 2012,  2012, 2012,
 start_month                 = 06,    06,   06,
 start_day                   = 28,    28,   28,
 start_hour                  = 00,    00,   00,
 start_minute                = 00,    00,   00,
 start_second                = 00,    00,   00,
 end_year                    = 2012,  2012, 2012,
 end_month                   = 07,    07,   07,
 end_day                     = 02,    02,   02,
 end_hour                    = 00,    00,   00,
 end_minute                  = 00,    00,   00,
 end_second                  = 00,    00,   00,
 interval_seconds            = 21600
 input_from_file             = .true.,.true.,.true.,
 history_interval            = 60,  10, 10,
 frames_per_outfile          = 1,  1, 1,
 history_outname             =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfout_d<domain>_<date>"
 restart                     = .false.,
 restart_interval            = 1440,
 override_restart_timers     = .true.,
 io_form_history             = 11
 io_form_restart             = 2
 io_form_input               = 2
 io_form_boundary            = 11
 io_form_auxinput2           = 11
 io_form_auxhist2            = 11
 debug_level                 = 10
 nocolons                    = .true.,
 auxinput4_inname            = "wrflowinp_d<domain>",
 auxinput4_interval          = 1440,  1440,  1440,
 io_form_auxinput4           = 2,
 auxinput1_inname            = "/data/derecho/met_files/ERA-I/met_em.d<domain>.<date>"
 iofields_filename           = "my_file_d01.txt", "my_file_d02.txt", "my_file_d03.txt",
 ignore_iofields_warning     = .true.,
 auxhist1_outname            =
"/data/derecho/WRF_output/NE_2012/aux1/auxhist1_d<domain>_<date>"
 auxhist1_interval           = 60,  60,  60,
 frames_per_auxhist1         = 1,  1,  1,
 io_form_auxhist1            = 11,
 output_diagnostics          = 1,
```

Author's response to reviewer #1 and reviewer #2:

```
 auxhist3_outname                    =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfxtrm_d<domain>_<date>"
 auxhist3_interval                   = 60, 10, 10,
 frames_per_auxhist3                 = 1, 1, 1,
 io_form_auxhist3                    = 11,
/
 &domains
 time_step                           = 30,
 time_step_fract_num                 = 0,
 time_step_fract_den                 = 1,
 max_dom                             = 3,
 e_we                                = 175,    262,   295,
 e_sn                                = 175,    262,   295,
 e_vert                              = 41,     41,    41,
 p_top_requested                     = 5000,
 sfcp_to_sfcp                        = .true.,
 num_metgrid_levels                  = 61,
 num_metgrid_soil_levels             = 4,
 dx                                  = 12000, 4000, 1333.33,
 dy                                  = 12000, 4000, 1333.33,
 grid_id                             = 1,     2,    3,
 parent_id                           = 1,     1,    2,
 i_parent_start                      = 1,     60,   105,
 j_parent_start                      = 1,     35,   75,
 parent_grid_ratio                   = 1,     3,    3,
 parent_time_step_ratio              = 1,     3,    3,
 feedback                            = 0,
 max_ts_locs                         = 0,
 eta_levels                          = 1.0000 , 0.9958 , 0.9916 , 0.9874 , 0.9832 ,
                                    0.9790 , 0.9749 , 0.9707 , 0.9661 , 0.9609 ,
                                    0.9549 , 0.9480 , 0.9398 , 0.9303 , 0.9189 ,
                                    0.9054 , 0.8894 , 0.8704 , 0.8481 , 0.8221 ,
                                    0.7922 , 0.7583 , 0.7205 , 0.6791 , 0.6346 ,
                                    0.5877 , 0.5393 , 0.4900 , 0.4407 , 0.3922 ,
                                    0.3450 , 0.2996 , 0.2564 , 0.2156 , 0.1773 ,
                                    0.1417 , 0.1086 , 0.0755 , 0.0475 , 0.0224 ,
                                    0.0000,
/
 &physics
 mp_physics                          = 9,     9,     9,
 ra_lw_physics                       = 1,     1,     1,
 ra_sw_physics                       = 1,     1,     1,
 radt                                = 10,    10,    10,
 sf_sfclay_physics                   = 1,     1,     1,
 sf_surface_physics                  = 2,     2,     2,
 bl_pbl_physics                      = 5,     5,     5,
 bldt                                = 0,     0,     0,
```

Author's response to reviewer #1 and reviewer #2:

```
cu_physics                  = 1,     0,     0,
cudt                        = 5,
isfflx                      = 1,
ifsnow                      = 1,
icloud                      = 1,
surface_input_source        = 3,
num_soil_layers             = 4,
num_land_cat                = 21,
sf_urban_physics            = 0,     0,     0,
bl_mynn_tkebudget           = 1,     1,     1,
bl_mynn_tkeadvect           = .true., .true., .true.,
rdmaxalb                    = .false.,
sst_update                  = 1,
tmn_update                  = 1,
usemonalb                   = .true.,
lagday                      = 150,
sst_skin                    = 1,
slope_rad                   = 1,  1,  1,
prec_acc_dt                 = 60., 10., 10.,
fractional_seaice           = 1,
seaice_threshold            = 0.,
/
&noah_mp
dveg                        = 4,
opt_crs                     = 1,
opt_btr                     = 2,
opt_run                     = 3,
opt_sfc                     = 1,
opt_frz                     = 1,
opt_inf                     = 1,
opt_rad                     = 3,
opt_alb                     = 2,
opt_snf                     = 4,
opt_tbot                    = 1,
opt_stc                     = 3,
/
&dynamics
w_damping                   = 1,
diff_opt                    = 1,      1,      1,
km_opt                      = 4,      4,      4,
diff_6th_opt                = 0,      0,      0,
diff_6th_factor             = 0.12,   0.12,   0.12,
base_temp                   = 290.
damp_opt                    = 0,
zdamp                       = 5000.,  5000.,  5000.,
dampcoef                    = 0.01,   0.01,  0.01,
khdif                       = 0,      0,
```

```
kvdif                    = 0,      0,
non_hydrostatic          = .true., .true., .true.,
/
&bdy_control
spec_bdy_width           = 5,
spec_zone                = 1,
relax_zone               = 4,
spec_exp                 = 0.13
specified                = .true., .false., .false.,
nested                   = .false., .true., .true.,
/
&grib2
/
&namelist_quilt
nio_tasks_per_group = 0,
nio_groups = 1,
/
```

Author's response to reviewer #1 and reviewer #2:

ERA5 nudged namelist

```
&time_control
 run_days                            = 6,
 run_hours                           = 0,
 run_minutes                         = 0,
 run_seconds                         = 0,
 start_year                          = 2012, 2012, 2012,
 start_month                         = 06,   06,   06,
 start_day                           = 26,   26,   26,
 start_hour                          = 00,   00,   00,
 start_minute                        = 00,   00,   00,
 start_second                        = 00,   00,   00,
 end_year                            = 2012, 2012, 2012,
 end_month                           = 07,   07,   07,
 end_day                             = 02,   02,   02,
 end_hour                            = 00,   00,   00,
 end_minute                          = 00,   00,   00,
 end_second                          = 00,   00,   00,
 interval_seconds                    = 21600
 input_from_file                     = .true.,.true.,.true.,
 history_interval                    = 60, 10, 10,
 frames_per_outfile                  = 1, 1, 1,
 history_outname                     =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfout_d<domain>_<date>"
 restart                             = .false.,
 restart_interval                    = 1440,
 override_restart_timers             = .true.,
 io_form_history                     = 11
 io_form_restart                     = 2
 io_form_input                       = 2
 io_form_boundary                    = 11
 io_form_auxinput2                   = 11
 io_form_auxhist2                    = 11
 debug_level                         = 10
 nocolons                            = .true.,
 auxinput4_inname                    = "wrflowinp_d<domain>",
 auxinput4_interval                  = 1440, 1440, 1440,
 io_form_auxinput4                   = 2,
 auxinput1_inname                    = "/data/derecho/met_files/ERA5/met_em.d<domain>.<date>"
 iofields_filename                   = "my_file_d01.txt", "my_file_d02.txt", "my_file_d03.txt",
 ignore_iofields_warning             = .true.,
 auxhist1_outname                    =
"/data/derecho/WRF_output/NE_2012/aux1/auxhist1_d<domain>_<date>"
 auxhist1_interval                   = 60, 60, 60,
 frames_per_auxhist1                 = 1, 1, 1,
 io_form_auxhist1                    = 11,
 output_diagnostics                  = 1,
```

```
 auxhist3_outname                    =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfxtrm_d<domain>_<date>"
 auxhist3_interval                   = 60, 10, 10,
 frames_per_auxhist3                 = 1, 1, 1,
 io_form_auxhist3                    = 11,
/
 &fdda
 grid_fdda                           = 1, 1, 1,
 gfdda_inname                        = "wrffdda_d<domain>",
 gfdda_end_h                         = 144, 144, 144,
 gfdda_interval_m                    = 360, 360, 360,
 fgdt                                = 0, 0, 0,
 if_no_pbl_nudging_uv                = 1, 1, 1,
 if_no_pbl_nudging_t                 = 1, 1, 1,
 if_no_pbl_nudging_q                 = 1, 1, 1,
 if_zfac_uv                          = 1, 1, 1,
 k_zfac_uv                           = 20, 20, 20,
 if_zfac_t                           = 1, 1, 1,
 k_zfac_t                            = 20, 20, 20,
 if_zfac_q                           = 1, 1, 1,
 k_zfac_q                            = 20, 20, 20,
 guv                                 = 0.0003, 0.0003, 0.0003,
 gt                                  = 0.0003, 0.0003, 0.0003,
 gq                                  = 0.0003, 0.0003, 0.0003,
 if_ramping                          = 1,
 dtramp_min                          = 60.0,
 io_form_gfdda                       = 11,
/
 &domains
 time_step                           = 30,
 time_step_fract_num                 = 0,
 time_step_fract_den                 = 1,
 max_dom                             = 3,
 e_we                                = 175,   262,   295,
 e_sn                                = 175,   262,   295,
 e_vert                              = 41,    41,    41,
 p_top_requested                     = 5000,
 sfcp_to_sfcp                        = .true.,
 num_metgrid_levels                  = 38,
 num_metgrid_soil_levels             = 4,
 dx                                  = 12000, 4000, 1333.33,
 dy                                  = 12000, 4000, 1333.33,
 grid_id                             = 1,     2,     3,
 parent_id                           = 1,     1,     2,
 i_parent_start                      = 1,     60,    105,
 j_parent_start                      = 1,     35,    75,
 parent_grid_ratio                   = 1,     3,     3,
```

Author's response to reviewer #1 and reviewer #2:

```
parent_time_step_ratio            = 1,     3,    3,
feedback                          = 0,
max_ts_locs                       = 0,
eta_levels                        = 1.0000 , 0.9958 , 0.9916 , 0.9874 , 0.9832 ,
                                  0.9790 , 0.9749 , 0.9707 , 0.9661 , 0.9609 ,
                                  0.9549 , 0.9480 , 0.9398 , 0.9303 , 0.9189 ,
                                  0.9054 , 0.8894 , 0.8704 , 0.8481 , 0.8221 ,
                                  0.7922 , 0.7583 , 0.7205 , 0.6791 , 0.6346 ,
                                  0.5877 , 0.5393 , 0.4900 , 0.4407 , 0.3922 ,
                                  0.3450 , 0.2996 , 0.2564 , 0.2156 , 0.1773 ,
                                  0.1417 , 0.1086 , 0.0755 , 0.0475 , 0.0224 ,
                                  0.0000,
/
&physics
mp_physics                        = 9,     9,     9,
ra_lw_physics                     = 1,     1,     1,
ra_sw_physics                     = 1,     1,     1,
radt                              = 10,    10,    10,
sf_sfclay_physics                 = 1,     1,     1,
sf_surface_physics                = 2,     2,     2,
bl_pbl_physics                    = 5,     5,     5,
bldt                              = 0,     0,     0,
cu_physics                        = 1,     0,     0,
cudt                              = 5,
isfflx                            = 1,
ifsnow                            = 1,
icloud                            = 1,
surface_input_source              = 3,
num_soil_layers                   = 4,
num_land_cat                      = 21,
sf_urban_physics                  = 0,     0,     0,
bl_mynn_tkebudget                 = 1,     1,     1,
bl_mynn_tkeadvect                 = .true., .true., .true.,
rdmaxalb                          = .false.,
sst_update                        = 1,
tmn_update                        = 1,
usemonalb                         = .true.,
lagday                            = 150,
sst_skin                          = 1,
slope_rad                         = 1,  1,  1,
prec_acc_dt                       = 60., 10., 10.,
fractional_seaice                 = 1,
seaice_threshold                  = 0.,
/
&noah_mp
dveg                              = 4,
opt_crs                           = 1,
```

Author's response to reviewer #1 and reviewer #2:

```
 opt_btr                        = 2,
 opt_run                        = 3,
 opt_sfc                        = 1,
 opt_frz                        = 1,
 opt_inf                        = 1,
 opt_rad                        = 3,
 opt_alb                        = 2,
 opt_snf                        = 4,
 opt_tbot                       = 1,
 opt_stc                        = 3,
/
 &dynamics
 w_damping                      = 1,
 diff_opt                       = 1,      1,      1,
 km_opt                         = 4,      4,      4,
 diff_6th_opt                   = 0,      0,      0,
 diff_6th_factor                = 0.12,   0.12,   0.12,
 base_temp                      = 290.
 damp_opt                       = 0,
 zdamp                          = 5000.,  5000.,  5000.,
 dampcoef                       = 0.01,    0.01,  0.01,
 khdif                          = 0,      0,
 kvdif                          = 0,      0,
 non_hydrostatic                = .true., .true., .true.,
 /
 &bdy_control
 spec_bdy_width                 = 5,
 spec_zone                      = 1,
 relax_zone                     = 4,
 spec_exp                       = 0.13
 specified                      = .true., .false., .false.,
 nested                         = .false., .true., .true.,
 /
 &grib2
 /
 &namelist_quilt
 nio_tasks_per_group = 0,
 nio_groups = 1,
 /
```

Shepherd T.J., Letson F., Barthelmie R.J. and Pryor S.C. How well are hazards associated with derechos reproduced in regional climate simulations? *Natural Hazards and Earth System Sciences Discussions (*nhess-2021-373)

Author's response to reviewer #1 and reviewer #2:

ERA-I nudged namelist

```
&time_control
 run_days                 = 6,
 run_hours                = 0,
 run_minutes              = 0,
 run_seconds              = 0,
 start_year               = 2012,  2012, 2012,
 start_month              = 06,    06,   06,
 start_day                = 26,    26,   26,
 start_hour               = 00,    00,   00,
 start_minute             = 00,    00,   00,
 start_second             = 00,    00,   00,
 end_year                 = 2012,  2012, 2012,
 end_month                = 07,    07,   07,
 end_day                  = 02,    02,   02,
 end_hour                 = 00,    00,   00,
 end_minute               = 00,    00,   00,
 end_second               = 00,    00,   00,
 interval_seconds         = 21600
 input_from_file          = .true.,.true.,.true.,
 history_interval         = 60,  10, 10,
 frames_per_outfile       = 1,  1, 1,
 history_outname          =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfout_d<domain>_<date>"
 restart                  = .false.,
 restart_interval         = 1440,
 override_restart_timers  = .true.,
 io_form_history          = 11
 io_form_restart          = 2
 io_form_input            = 2
 io_form_boundary         = 11
 io_form_auxinput2        = 11
 io_form_auxhist2         = 11
 debug_level              = 10
 nocolons                 = .true.,
 auxinput4_inname         = "wrflowinp_d<domain>",
 auxinput4_interval       = 1440,  1440,  1440,
 io_form_auxinput4        = 2,
 auxinput1_inname         = "/data/derecho/met_files/ERA-I/met_em.d<domain>.<date>"
 iofields_filename        = "my_file_d01.txt", "my_file_d02.txt", "my_file_d03.txt",
 ignore_iofields_warning  = .true.,
 auxhist1_outname         =
"/data/derecho/WRF_output/NE_2012/aux1/auxhist1_d<domain>_<date>"
 auxhist1_interval        = 60,  60,  60,
 frames_per_auxhist1      = 1,  1,  1,
 io_form_auxhist1         = 11,
 output_diagnostics       = 1,
```

Author's response to reviewer #1 and reviewer #2:

```
 auxhist3_outname                    =
"/data/derecho/WRF_output/NE_2012/wrfout/wrfxtrm_d<domain>_<date>"
 auxhist3_interval                   = 60, 10, 10,
 frames_per_auxhist3                 = 1, 1, 1,
 io_form_auxhist3                    = 11,
/
 &fdda
 grid_fdda                           = 1, 1, 1,
 gfdda_inname                        = "wrffdda_d<domain>",
 gfdda_end_h                         = 144, 144, 144,
 gfdda_interval_m                    = 360, 360, 360,
 fgdt                                = 0, 0, 0,
 if_no_pbl_nudging_uv                = 1, 1, 1,
 if_no_pbl_nudging_t                 = 1, 1, 1,
 if_no_pbl_nudging_q                 = 1, 1, 1,
 if_zfac_uv                          = 1, 1, 1,
 k_zfac_uv                           = 20, 20, 20,
 if_zfac_t                           = 1, 1, 1,
 k_zfac_t                            = 20, 20, 20,
 if_zfac_q                           = 1, 1, 1,
 k_zfac_q                            = 20, 20, 20,
 guv                                 = 0.0003, 0.0003, 0.0003,
 gt                                  = 0.0003, 0.0003, 0.0003,
 gq                                  = 0.0003, 0.0003, 0.0003,
 if_ramping                          = 1,
 dtramp_min                          = 60.0,
 io_form_gfdda                       = 11,
/
 &domains
 time_step                           = 30,
 time_step_fract_num                 = 0,
 time_step_fract_den                 = 1,
 max_dom                             = 3,
 e_we                                = 175,    262,   295,
 e_sn                                = 175,    262,   295,
 e_vert                              = 41,     41,    41,
 p_top_requested                     = 5000,
 sfcp_to_sfcp                        = .true.,
 num_metgrid_levels                  = 61,
 num_metgrid_soil_levels             = 4,
 dx                                  = 12000, 4000, 1333.33,
 dy                                  = 12000, 4000, 1333.33,
 grid_id                             = 1,     2,     3,
 parent_id                           = 1,     1,     2,
 i_parent_start                      = 1,     60,    105,
 j_parent_start                      = 1,     35,    75,
 parent_grid_ratio                   = 1,     3,     3,
```

Author's response to reviewer #1 and reviewer #2:

```
 parent_time_step_ratio            = 1,     3,    3,
 feedback                          = 0,
 max_ts_locs                       = 0,
 eta_levels                        = 1.0000 , 0.9958 , 0.9916 , 0.9874 , 0.9832 ,
                                   0.9790 , 0.9749 , 0.9707 , 0.9661 , 0.9609 ,
                                   0.9549 , 0.9480 , 0.9398 , 0.9303 , 0.9189 ,
                                   0.9054 , 0.8894 , 0.8704 , 0.8481 , 0.8221 ,
                                   0.7922 , 0.7583 , 0.7205 , 0.6791 , 0.6346 ,
                                   0.5877 , 0.5393 , 0.4900 , 0.4407 , 0.3922 ,
                                   0.3450 , 0.2996 , 0.2564 , 0.2156 , 0.1773 ,
                                   0.1417 , 0.1086 , 0.0755 , 0.0475 , 0.0224 ,
                                   0.0000,
/
 &physics
 mp_physics                        = 9,     9,     9,
 ra_lw_physics                     = 1,     1,     1,
 ra_sw_physics                     = 1,     1,     1,
 radt                              = 10,    10,    10,
 sf_sfclay_physics                 = 1,     1,     1,
 sf_surface_physics                = 2,     2,     2,
 bl_pbl_physics                    = 5,     5,     5,
 bldt                              = 0,     0,     0,
 cu_physics                        = 1,     0,     0,
 cudt                              = 5,
 isfflx                            = 1,
 ifsnow                            = 1,
 icloud                            = 1,
 surface_input_source              = 3,
 num_soil_layers                   = 4,
 num_land_cat                      = 21,
 sf_urban_physics                  = 0,     0,     0,
 bl_mynn_tkebudget                 = 1,     1,     1,
 bl_mynn_tkeadvect                 = .true., .true., .true.,
 rdmaxalb                          = .false.,
 sst_update                        = 1,
 tmn_update                        = 1,
 usemonalb                         = .true.,
 lagday                            = 150,
 sst_skin                          = 1,
 slope_rad                         = 1,  1,  1,
 prec_acc_dt                       = 60., 10., 10.,
 fractional_seaice                 = 1,
 seaice_threshold                  = 0.,
 /
 &noah_mp
 dveg                              = 4,
 opt_crs                           = 1,
```

Author's response to reviewer #1 and reviewer #2:

```
 opt_btr                        = 2,
 opt_run                        = 3,
 opt_sfc                        = 1,
 opt_frz                        = 1,
 opt_inf                        = 1,
 opt_rad                        = 3,
 opt_alb                        = 2,
 opt_snf                        = 4,
 opt_tbot                       = 1,
opt_stc                         = 3,
/
 &dynamics
 w_damping                      = 1,
 diff_opt                       = 1,      1,      1,
 km_opt                         = 4,      4,      4,
 diff_6th_opt                   = 0,      0,      0,
 diff_6th_factor                = 0.12,   0.12,   0.12,
 base_temp                      = 290.
 damp_opt                       = 0,
 zdamp                          = 5000.,  5000.,  5000.,
 dampcoef                       = 0.01,    0.01,  0.01,
 khdif                          = 0,      0,
 kvdif                          = 0,      0,
 non_hydrostatic                = .true., .true., .true.,
 /
 &bdy_control
 spec_bdy_width                 = 5,
 spec_zone                      = 1,
 relax_zone                     = 4,
 spec_exp                       = 0.13
 specified                      = .true., .false., .false.,
 nested                         = .false., .true., .true.,
 /
 &grib2
 /
 &namelist_quilt
 nio_tasks_per_group = 0,
 nio_groups = 1,
 /
```

Shepherd T.J., Letson F., Barthelmie R.J. and Pryor S.C. How well are hazards associated with derechos reproduced in regional climate simulations? *Natural Hazards and Earth System Sciences Discussions (*nhess-2021-373)

Author's response to reviewer #1 and reviewer #2:

Response to reviewer 2:

We thank the reviewer for their insightful and thought-provoking comments. Below we provide a complete list of their comments (in black) and our responses (in green). We further note in brief how this material will be included in the manuscript. **We have provided the line numbers in bold for the revisions in the revised manuscript**.

Review of nhess-2021-373: How well are hazards associated with derechos reproduced in regional climate simulations?
The authors used WRF as a convective-permitting regional climate model to produce 11 simulations of a severe derecho that affected the northeastern U.S. in 2012. The derecho had a major impact in terms of property damage and power outages over a large, populated region. This derecho was poorly forecast, yet we need to understand how climate change will impact such extreme mesoconvective systems. The authors examined the role of microphysical parametrization, nudging, and two different reanalysis products on 3km simulations of several days leading up to and including the derecho. The authors compared model output to surface and radar observations of precipitation, wind gust, hail, as well as variables describing the convective environment, such as vertical velocities and cold pool formation. The explanation of the methods of model assessment was particularly thoughtful.
Overall, the manuscript is well constructed with clear objectives, detailed methodology, and significant findings. I recommend that the manuscript be accepted following minor revisions.

Major comments

1. While most of the simulations poorly represented the derecho, this is not surprising given that this event was not well predicted. While I would not ask the authors to address in this manuscript, it would be intriguing to duplicate this work for a significant mesoconvective system that was well predicted.

Response: We appreciate the reviewer's comment. We do indeed plan to explore this work further, particularly in the context of pseudo global warming studies. As per minor comment 10, we have included references to such studies that are relevant to mesoscale convective systems in North America.

2. While the use of the different microphysical parameterizations in the model was well designed, it is unclear what is learned by the comparison of ERA5 and ERA-Interim. It is not clear to me that you can generalize that ERA-Interim is inherently better at producing boundary conditions for such simulations (l. 526-527), or whether the small differences in the pre-storm temperature and moisture fields in ERA-Interim (l. 413-415) fortuitously produced more realistic simulations.

Response: We thank the reviewer for presenting this concern. We do agree that the over-generalization of the initial condition results is not warranted. For this reason, we were particularly careful with the language used to not assert one dataset as being more accurate, but rather to explain why the simulations differed. We note the reviewer's concern, however, and have revised the manuscript text. The text at line 526-527 in the original manuscript has been amended to (**inserted at lines633 – 634 in the revised text**): "Additional simulations using ERA5 and ERA-I are required before generalizable conclusions can be made about which dataset provides better boundary conditions."

For lines 413-415 in the original manuscript, we note that we have already revised the manuscript text in response to reviewer 1 and their comments regarding the simulations. After additional research, the elevated mixed layer (EML) proved to be critical in this event. We note that there was a high degree of similarity between the two reanalysis products, but the key difference between the two initial conditions datasets is the coherency of the EML. This is one factor in the difference between simulations with ERA5 and ERA-I. The revised text reads (**inserted at lines 489 – 501 in the revised manuscript):**

"Evaluation of the initial conditions indicates a high degree of similarity between the two reanalysis products on 26 and 28 June for most properties (Figure 12). However, as described above, development of an intense elevated mixed layer (EML, 700-500 hPa) over the central US that subsequently propagated eastwards (Shourd and Kaplan, 2021) appears to have been a key ingredient in development of this Derecho. Earlier work (Banacos and Ekster, 2010) employed a definition of an EML as a layer of depth > 200 hPa with both a steep lapse rate (temperature declines of over 8°C per km) and an increase in the RH with height. Figure 12 shows the lapse rate in the four sets of IC and indicates that while both data sets correctly (relative to output from NOAA WRF-Rapid Refresh model presented in (Shourd and Kaplan, 2021)) indicate relatively low lapse rates at 0000Z 26 June (when the region with the EML was displaced further west), using the combined definition of a strong lapse rate and a strong gradient of RH (a 20% difference across the layer), the EML is, in both reanalysis products, displaced too far north at 0000Z 28 June relative to NOAA WRF-Rapid Refresh model simulations presented in (Shourd and Kaplan, 2021). The EML is, however, more consistent (across the two components) and more coherent in space in ERA-Interim. This may provide a partial explanation for why simulations with ERA-Interim initial and lateral boundary conditions exhibit higher fidelity with respect to aspects of the Derecho."

References

Banacos, P. C. and Ekster, M. L.: The Association of the Elevated Mixed Layer with Significant Severe Weather Events in the Northeastern United States, Weather and Forecasting, 25, 1082-1102, 10.1175/2010waf2222363.1, 2010.

Shourd, K. N. and Kaplan, M. L.: The Multiscale Dynamics of the 29 June 2012 Super Derecho, Climate, 9, 155, 2021

Author's response to reviewer #1 and reviewer #2:

3. I share the concern with the first reviewer that the abstract was not sufficiently specific, but I find the proposed new abstract in the authors' response to be a significant improvement that addresses this concern.

Response: We appreciate the reviewer's comment and thank them for reading the reply to reviewer 1 where we responded with the improved abstract.

4. I share the first reviewer's concern about the need for additional context on the convective environment for this storm in the background. The additions proposed by the authors appear to address this concern.

Response: Again, we thank the reviewer for reading the reply to reviewer 1 and we are pleased that the additions address these concerns.

Minor

1. 44: Is "atmospheric phenomena" another way of saying "weather"? Or is it intended to capture more.

Response: We are using this term in the AMS glossary sense; **atmospheric phenomenon**
As commonly used in weather observing practice, an observable occurrence of particular physical (as opposed to dynamic or synoptic) significance within the atmosphere.
Included are all hydrometeors (except clouds, which are usually considered separately), lithometeors, igneous meteors, and luminous meteors. From the viewpoint of weather observations, thunderstorms, tornadoes, waterspouts, and squalls are also included. The above usage excludes such "phenomena" as the local or large-scale characteristics of wind, pressure, and temperature; it also excludes clouds, although it includes many products of cloud development and composition. In aviation weather observation, atmospheric phenomena are divided into two categories: weather and obstructions to vision."
Which we believe is differentiable from 'weather', which again according to the AMS glossary has the following definition: **weather**
The state of the atmosphere, mainly with respect to its effects upon life and human activities.

As distinguished from climate, weather consists of the short-term (minutes to days) variations in the atmosphere. Popularly, weather is thought of in terms of temperature, humidity, precipitation, cloudiness, visibility, and wind.

1. As used in the taking of surface weather observations, a category of individual and combined atmospheric phenomena that must be drawn upon to describe the local atmospheric activity at the time of observation.
   Listed weather types include tornado, waterspout, funnel cloud, thunderstorm and severe storm, liquid precipitation(drizzle, rain, rain showers), freezing precipitation (freezing drizzle, freezing rain), and frozen precipitation (snow, snow pellets, snow grains, hail, ice pellets, ice crystals). These elements, with the exception of the first three, are denoted by a letter code in the observation. With the METAR code, reporting weather also includes an intensity qualifier (light, moderate, or heavy) or proximity

Author's response to reviewer #1 and reviewer #2:

qualifier. The weather used in synoptic weather observations and marine weather observations is reported in two categories, "present weather" and "past weather." The "present weather" table consists of 100 possible conditions, with 10 possibilities for "past weather"; both are encoded numerically. Another method, which has the advantage of being independent of language, is the recording of weather types using symbols. There are 100 symbols that identify with the numeric codes of the synoptic observation.

2. To undergo change due to exposure to the atmosphere.'

So, we perceive 'weather' as the totality of the atmospheric state and atmospheric phenomena as notable (perhaps even atypical) conditions that may derive from a singular event (e.g., downdrafts and lightning from MCS).
Nevertheless, given the reviewers concerns we have changed 'atmospheric phenomena' to 'weather events' (**inserted at line 49 in the revised manuscript**).

2. 54: focuses

Response: Thanks. Corrected (**line 60 in the revised manuscript**)

3. 51: "function model configuration" – appears a word is missing

Response: Thanks. We have corrected the sentence to read "…as a function of model configuration…" (**line 57 in the revised manuscript**).

4. 56: Is "advected" the right word? Perhaps "propagated"?

Response: Thanks for this suggestion. We now use 'propagated' instead of 'advected' (**line 62 in the revised manuscript**).

5. 66: run-on sentence

Response: Thanks for spotting this. The sentence now reads (**line 72 in the revised manuscript**): "Over 20 deaths were reported during the 29-30 June 2012 derecho event. There was also widespread property damage and extensive power outages (Halverson, 2014)."

6. 88-89: it might be helpful to explain "scale-aware convective parameterizations". How are they "scale-aware"?

Response: Thanks for this suggestion. We have added a brief definition of what scale-aware convection schemes are, by changing the sentence to read (**inserted at lines 116 – 118 in the revised manuscript**): "Emerging research has shown that using scale-aware convective parameterizations (i.e. those schemes where numerical descriptions include a parameter that modulates convective processes as a function of horizontal resolution) throughout the model gray zone resolution…".

Author's response to reviewer #1 and reviewer #2:

7. 93: "degree/manner in what the model parameterization interact" is unclear. What is this trying to say?

Response: Thanks for bringing this to our attention. We have amended this sentence to remove ambiguity. The revised text in the manuscript will read (**inserted at lines 122 – 123 in the revised manuscript**): "…model fidelity is a strong function of the precise cloud microphysics scheme applied, model grid spacing, lateral boundary conditions and the degree/manner in which the model parameterizations interact (for example, feedback between the cumulus parameterizations/cloud microphysics and the radiation scheme)"

8. 306: Perhaps I'm missing something obvious, but why would s(w) be used as intensity for vertical motion rather than just w?

Response: We note that the text at line 308 in the original manuscript states: "The height at which the maximum variability in vertical velocities occur is used to provide information regarding the vertical structure of convection." We have elaborated slightly to read (**inserted at lines 356 – 361 in the revised manuscript**):

"The height at which the maximum standard deviation of vertical velocities ($\sigma(w)$) is used to infer the intensity and vertical structure of convection. Since updrafts and downdrafts are of relatively short duration and small spatial extent, we use the spatial standard deviation $\sigma(w)$ computed using vertical velocities output from the time of maximum cREF > 40 dBZ (i.e. from the 10-min time step WRF output file at that time) considering all WRF grid cells within 50 km of cREF > 40 dBZ. This is a more descriptive metric rather than the mean velocity because the dispersion around the mean is reflective of the intensity of both downdrafts and updrafts in the column."

9. 322-323: This sentence (Rank correlation coefficients…") isn't clear. How does the rank correlation show which model property most greatly influences skill? The correlations show how well the model and observations agree, but the word "influences" suggests that you can determine a causal mechanism.

Response: We agree that this is ambiguous and could be misleading. We have amended the manuscript text to (**inserted at lines 376 – 377 in the revised manuscript**): "…to identify which model properties (wind speed, precipitation etc.) exhibit highest association with the diagnostic metrics used to examine model skill in simulating this event."

10. 501: The authors use the pseudo-global warming framework as a justification but don't provide references (perhaps I missed them) how this framework has been used to examine mesoconvective systems nor provide examples of how such a framework might be used.

Author's response to reviewer #1 and reviewer #2:

Response: Thanks for raising this. There are indeed a few PGW studies related to MCSs, but not specifically to derecho events [e.g., Liu et al. (2017); Haberlie et al. (2019)]. We have added these additional references to the manuscript text.

Thus, the previous text that read (line 521 in the original manuscript):

"Our finding has important implications for construction of hindcast simulations for use in Surrogate or Pseudo Global Warming (PGW) numerical experiments to quantify the potential of global warming on extreme weather events using regional models (Li et al., 2019). In such simulations an historically important extreme event is first simulated using contemporary LBC and then the simulation is repeated using LBC and IC perturbed to represent the change in, for example, air temperatures and water vapor availability. The difference in these two realizations is interpreted as the impact of global climate non-stationarity. Our work indicates use of ERA5 for IC and LBC may not always result in improved baseline simulations of the extreme event in the contemporary climate, and the simulation deficiencies may render evaluation of the PGW response highly uncertain."

Has been modified to read (**inserted at lines 623 – 634 in the revised manuscript**):

"Our finding has important implications for construction of hindcast simulations for use in Surrogate or Pseudo Global Warming (PGW) numerical experiments to quantify the potential of global warming on extreme weather events using regional models (Kröner et al., 2017; Liu et al., 2017; Haberlie and Ashley, 2019; Li et al., 2019). In such simulations an historically important extreme event/period/season is first simulated using contemporary LBC and then the simulation is repeated using LBC and IC perturbed to represent the change in, for example, air temperatures and water vapor availability (Kroner et al. 2017). The difference in these two realizations is interpreted as the impact of global climate non-stationarity. A previous analysis over CONUS used ERA-Interim LBC and shifted the atmospheric profile by ± 5 °C. They found increases in both CAPE and convective inhibition, which implies shift the convective population (Rasmussen et al. 2020). Our work indicates use of either ERA-Interim or ERA5 for IC and LBC may not always result in high-fidelity baseline simulations of extreme convective events in the contemporary climate. These simulation deficiencies may render evaluation of the PGW response highly uncertain. Additional simulations using ERA5 and ERA-I are required before generalizable conclusions can be made about which dataset provides better boundary conditions."

References:

Haberlie, A. M., & Ashley, W. S. (2019). Climatological representation of mesoscale convective systems in a dynamically downscaled climate simulation. International Journal of Climatology, 39(2), 1144-1153.

Author's response to reviewer #1 and reviewer #2:

Kröner, N., Kotlarski, S., Fischer, E., Lüthi, D., Zubler, E., & Schär, C. (2017). Separating climate change signals into thermodynamic, lapse-rate and circulation effects: theory and application to the European summer climate. *Climate Dynamics*, *48*(9), 3425-3440.

Liu, C., Ikeda, K., Rasmussen, R., Barlage, M., Newman, A.J., Prein, A.F., Chen, F., Chen, L., Clark, M., Dai, A., Dudhia, J., Eidhammer, T., Gochis, D., Gutmann, E., Kurkute, S., Li, Y., Thompson, G. and Yates, D. (2017) Continental-scale convection-permitting modeling of the current and future climate of north america. *Climate Dynamics*, **49**, 71–95.

Rasmussen, K. L., Prein, A. F., Rasmussen, R. M., Ikeda, K., & Liu, C. (2020). Changes in the convective population and thermodynamic environments in convection-permitting regional climate simulations over the United States. *Climate Dynamics*, *55*(1), 383-408.