Supplemental Materials

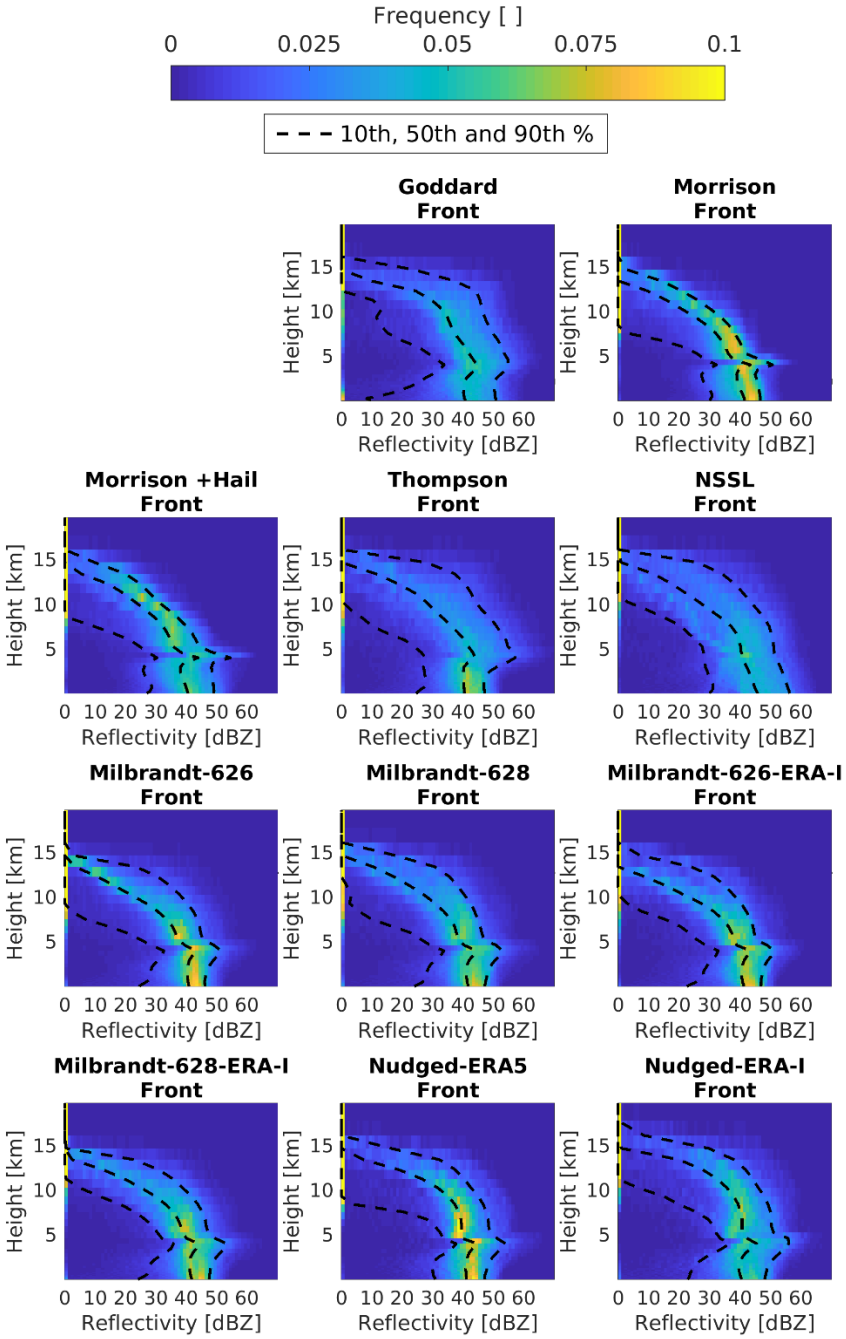

Figure S1: Distributions of derived RADAR reflectivity at each model height from each WRF ensemble member at t_p (i.e. the time of peak spatial extent of cREF > 40 dBZ during the Front period) during the Front period. The plot shows the frequency with which a given reflectivity is observed at a given height in output for all domain d03 grid cells where cREF > 40 dBZ. Dotted lines show the 10th 50th and 90th percentile reflectivity in those cells at each height.

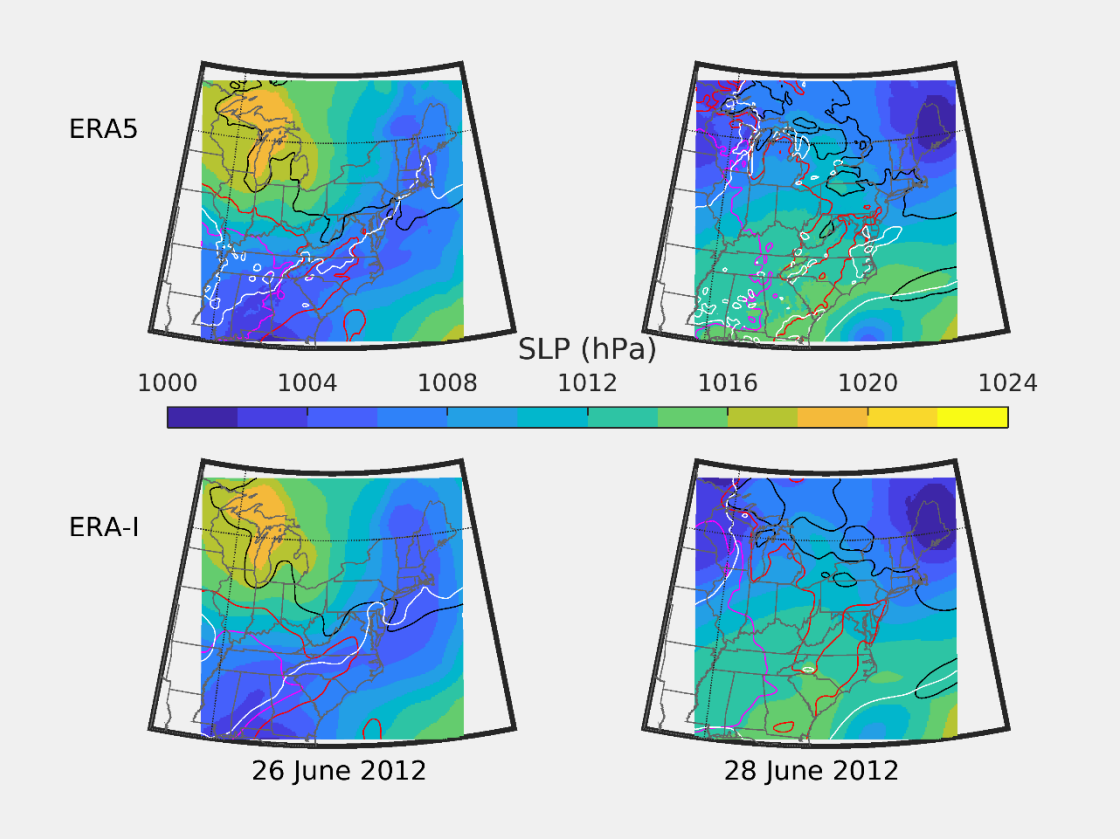

Figure S2: Spatial maps of sea level pressure (colored surface) generated by WRF real from the ERA5 and ERA-Interim reanalysis products used to initialize the model LBC and initial conditions. The black, red, and magenta lines are temperature at 2m of 295 K, 300 K, and 305 K respectively. The white line represents specific humidity at 2m (in g/kg) for a value of 12.5 g/kg. In the plot, WRF real output is used from all 3 domains, thus the data presented in this figure has varying resolution bounded by the individual domain boundaries, with domain 1 being the absolute boundary shown.

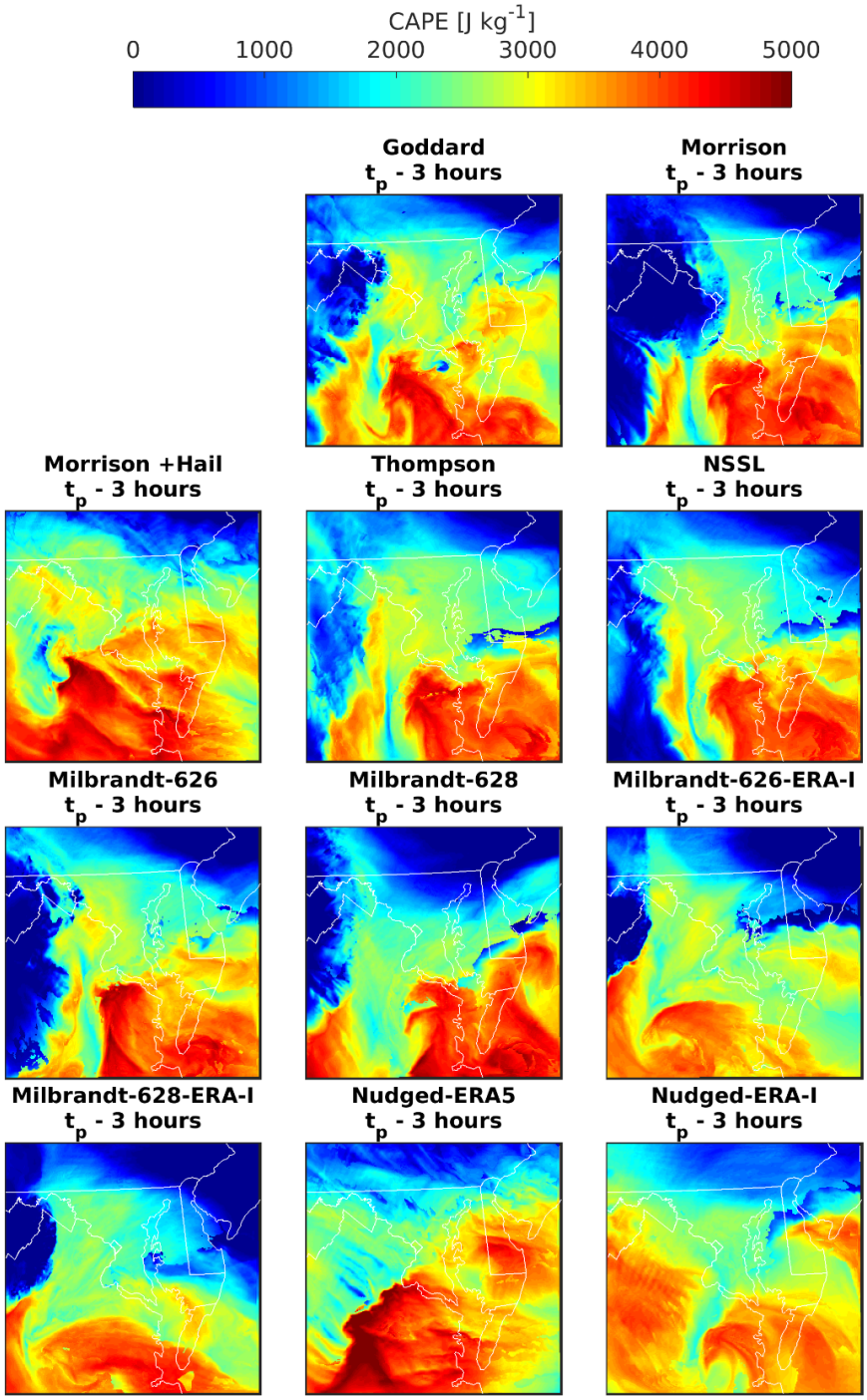

Figure S3: Spatial patterns of MU-CAPE at t_p-3 (i.e. 3 hours prior to the time of peak spatial extent of cREF > 40 dBZ during the Derecho period) over domain d03 for all ensemble members. These panels are also shown in Figure 12 of the main text but are included again here, enlarged for visibility.

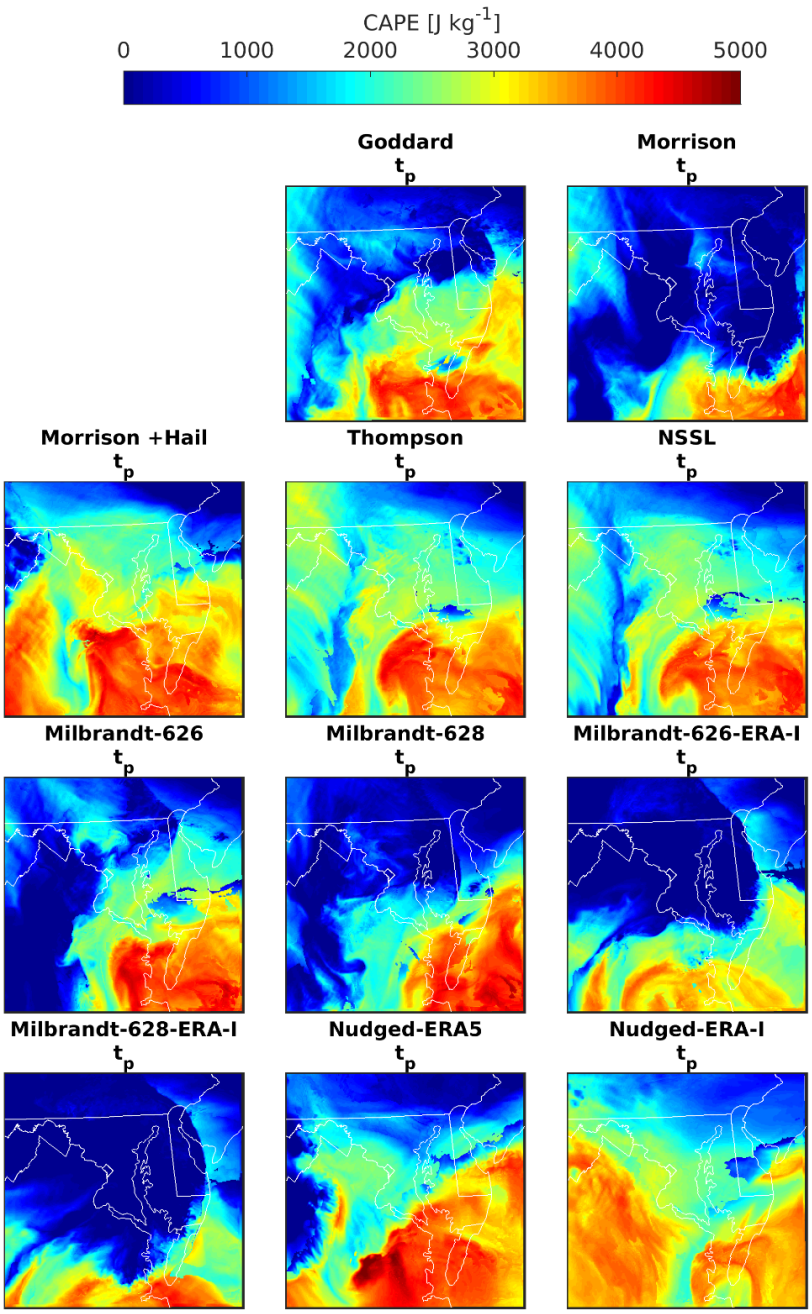

Figure S4: Spatial patterns of MU-CAPE at t_p (i.e. the time of peak spatial extent of cREF > 40 dBZ during the Derecho period) over domain d03 for all ensemble members. These panels are also shown in Figure 12 of the main text but are included again here, enlarged for visibility.

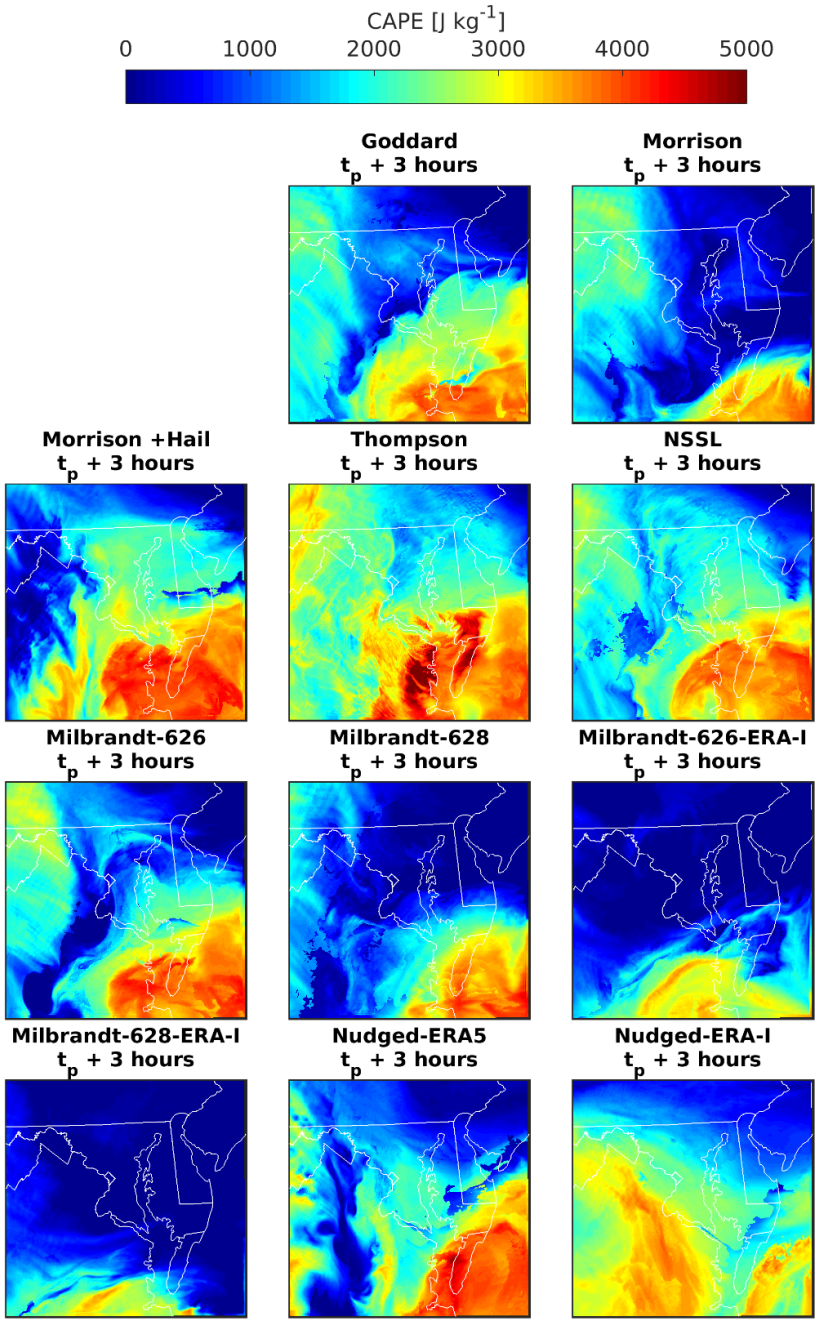

Figure S5: Spatial pattern of MU-CAPE at t_p + 3 hours (i.e. 3 hours after the time of peak spatial extent of cREF > 40 dBZ during the Derecho period) over domain d03 for all ensemble members. These panels are also shown in Figure 12 of the main text but are included again here, enlarged for visibility.

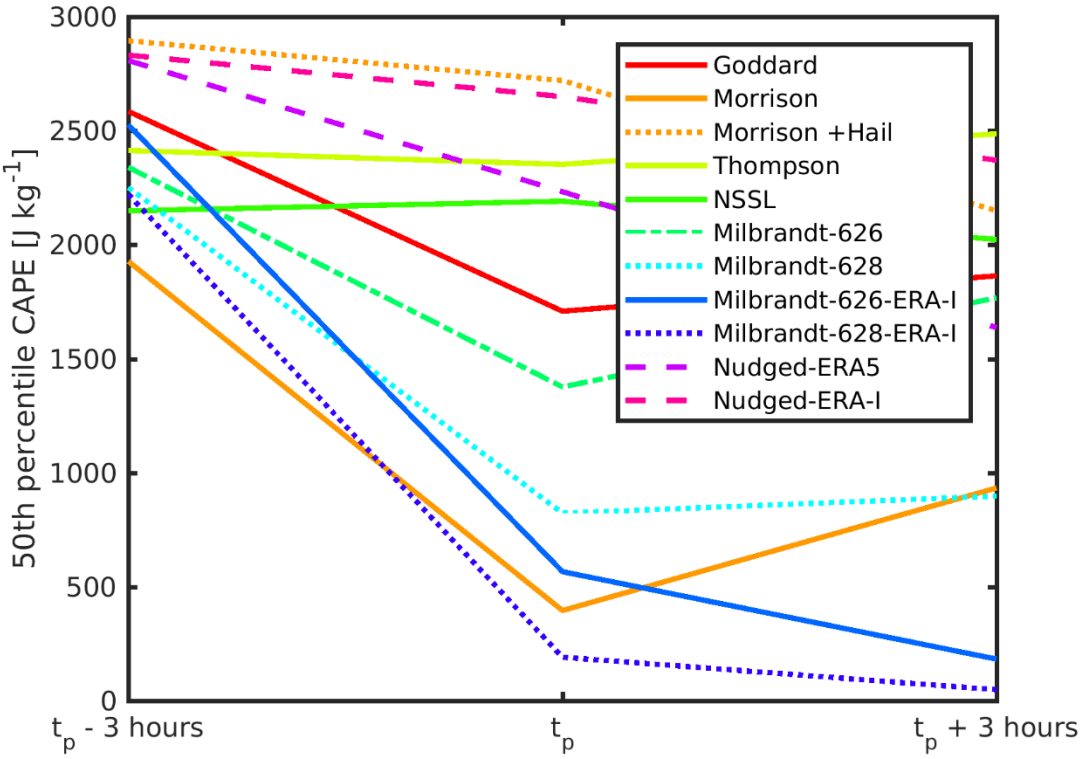

Figure S6: The spatial average (median) MU-CAPE in domain d03 cells in the six hours surrounding t_p (the time of peak spatial extent of cREF > 40 dBZ during the Derecho period) for each ensemble member.

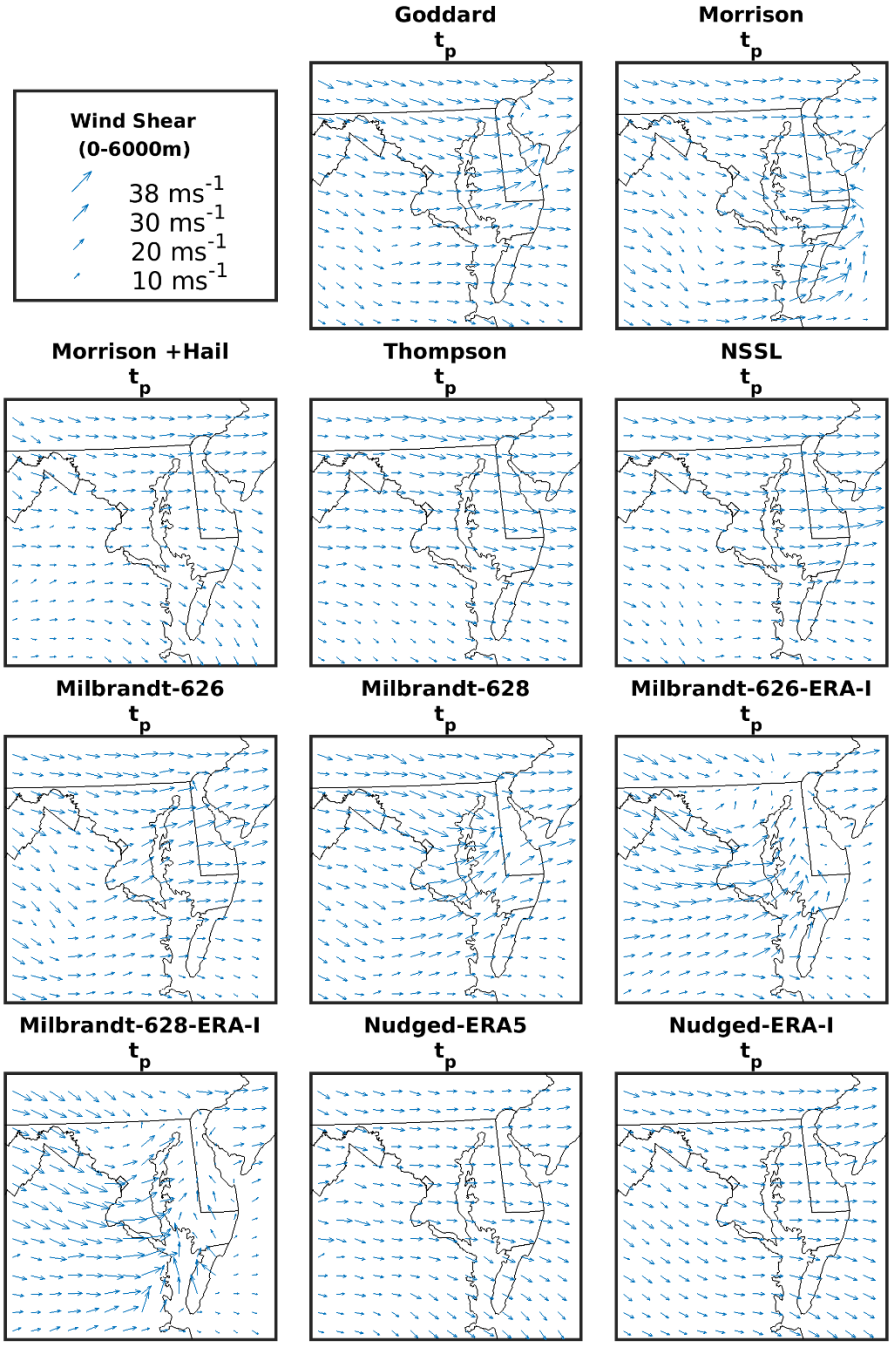

Figure S7: Total wind shear between the ground and 6000 m (S6) at t_p (the time of peak spatial extent of cREF > 40 dBZ during the Derecho period) for each ensemble member. These panels are also shown in Figure 12 of the main text but are included again here, enlarged for visibility.

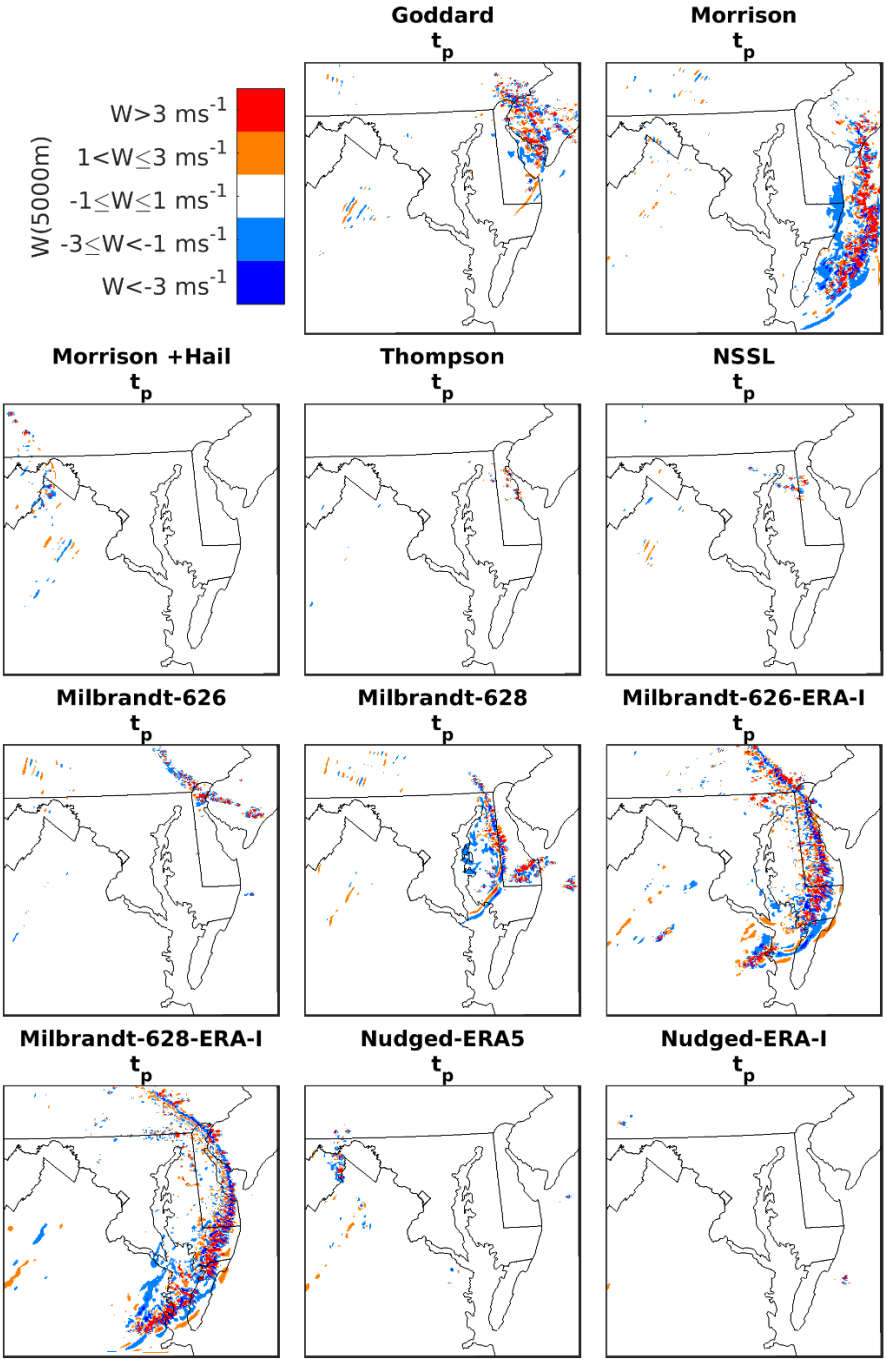

Figure S8: Vertical velocity (W) at 5000 m and t_p (the time of peak spatial extent of cREF > 40 dBZ during the Derecho period) for each ensemble member. $|W| > 1$ ms^{-1} are shown in four colored classes. These vertical velocities are also shown in Figure 12 of the main text but are included again here, enlarged for visibility.

Example namelist for the derecho simulations

```
&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                   =  "/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                                                    =
"/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                  =  "/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                  =  "/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,
```

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 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,
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 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,
/
```