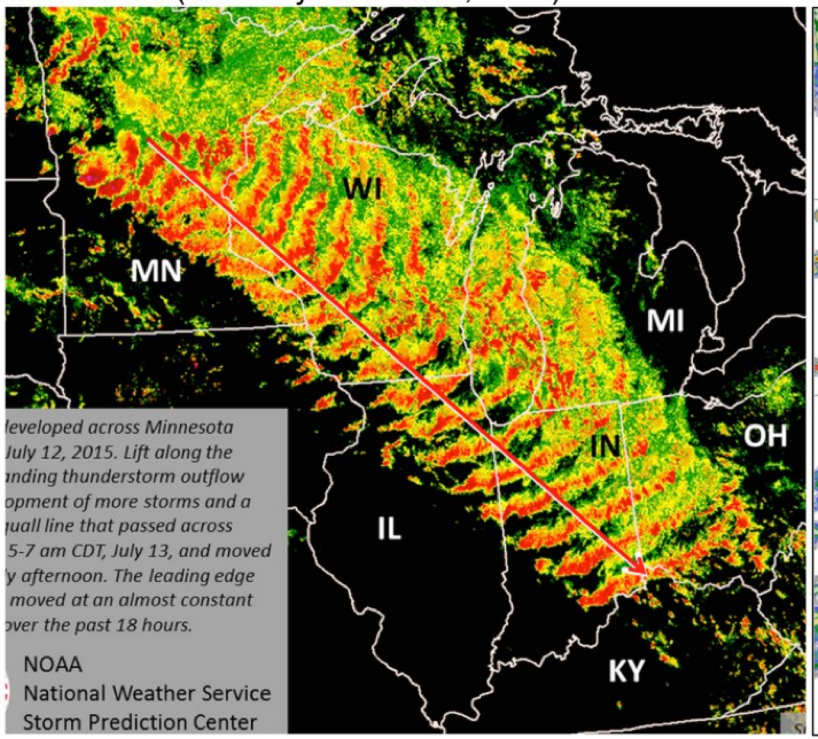
"Progress in Predicting Derechoes with the NCAR-WRF High-Resolution Ensemble"

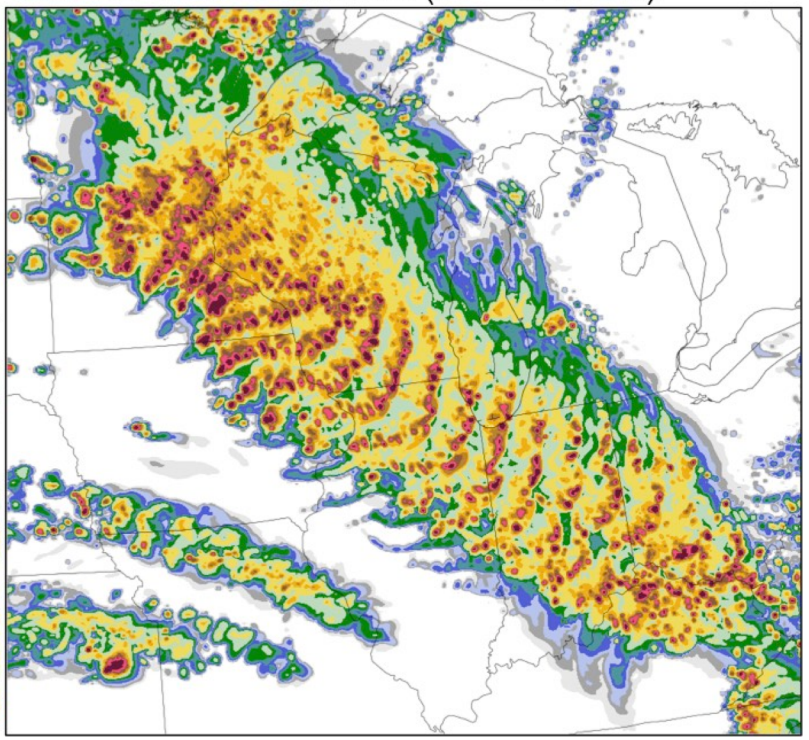
Morris Weisman, Craig Schwartz, Kevin Manning

2018 Joint WRF/MPAS User's Workshop

Observed (courtesy G. Carbin, SPC)



NCAR Ensemble Member (26 – 45 hr fcst)



July 12 2015 Derecho

10 Member 3 km Ensemble: ensemble.ucar.edu

(uses perturbed initial conditions)

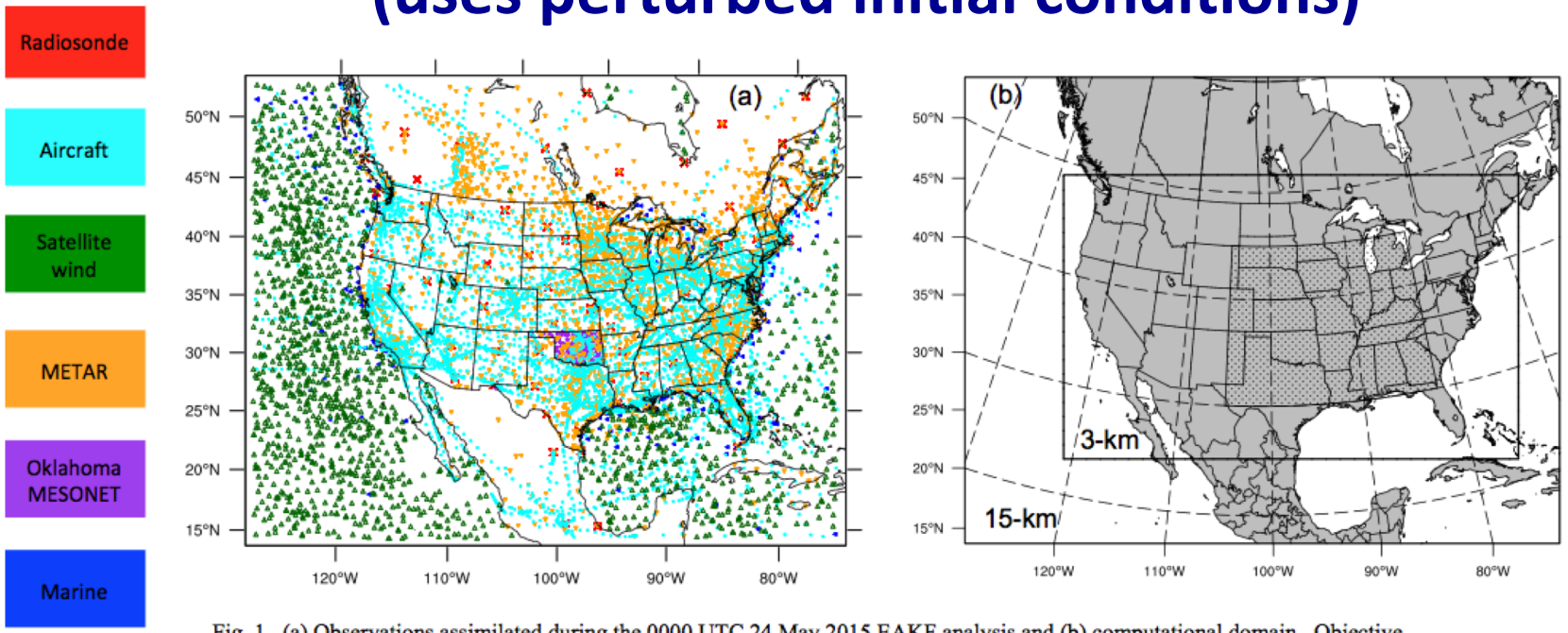
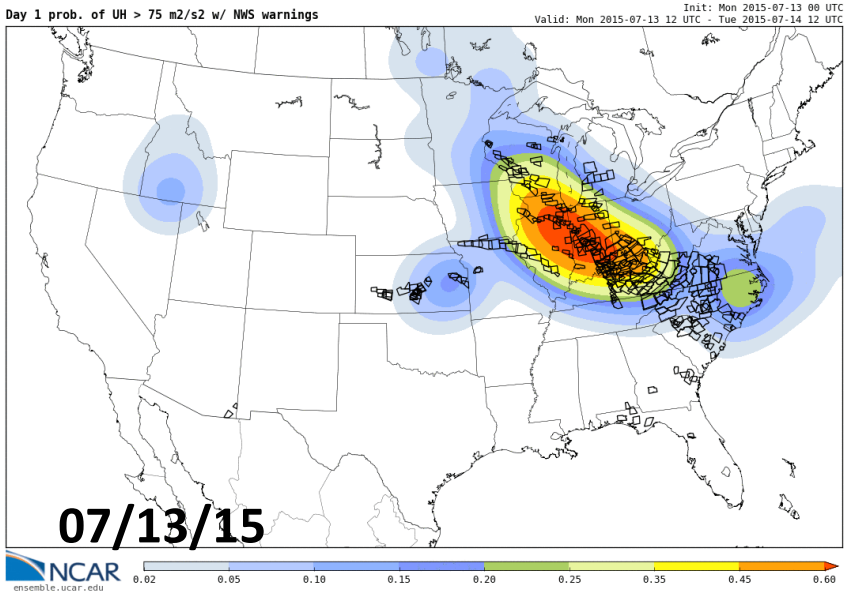


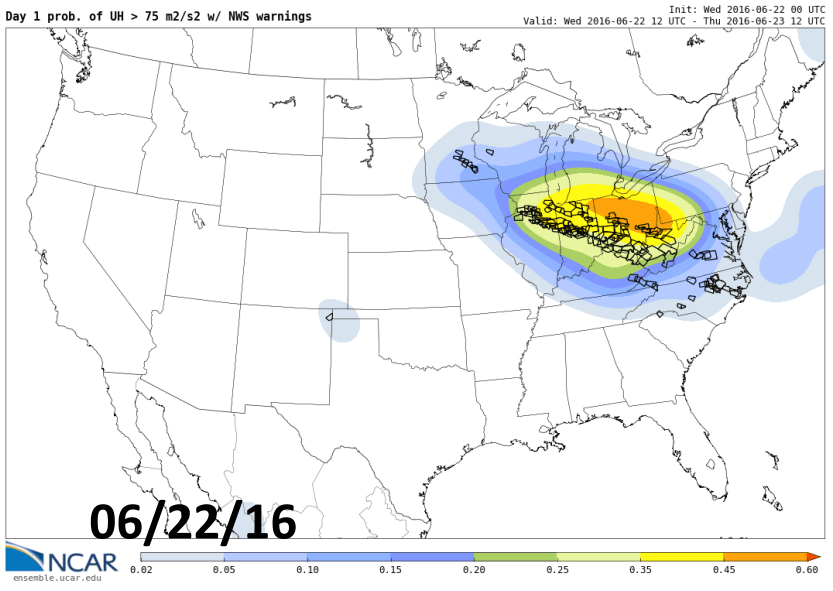
Fig. 1. (a) Observations assimilated during the 0000 UTC 24 May 2015 EAKF analysis and (b) computational domain. Objective precipitation verification only occurred over the speckled region of the 3-km domain.

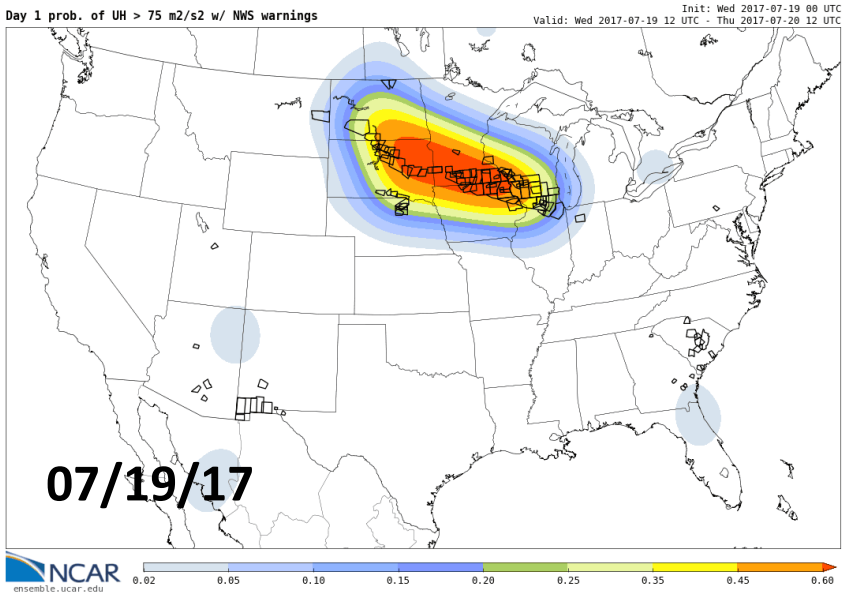
- Data Assimilation Research Testbed toolkit (Lanai)
- **Continuously cycled** (initialized mid-March 2015)
- Ensemble Adjustment Kalman Filter
- **50-member** analysis, updated every 6 h
- Assimilate **conventional observations**:

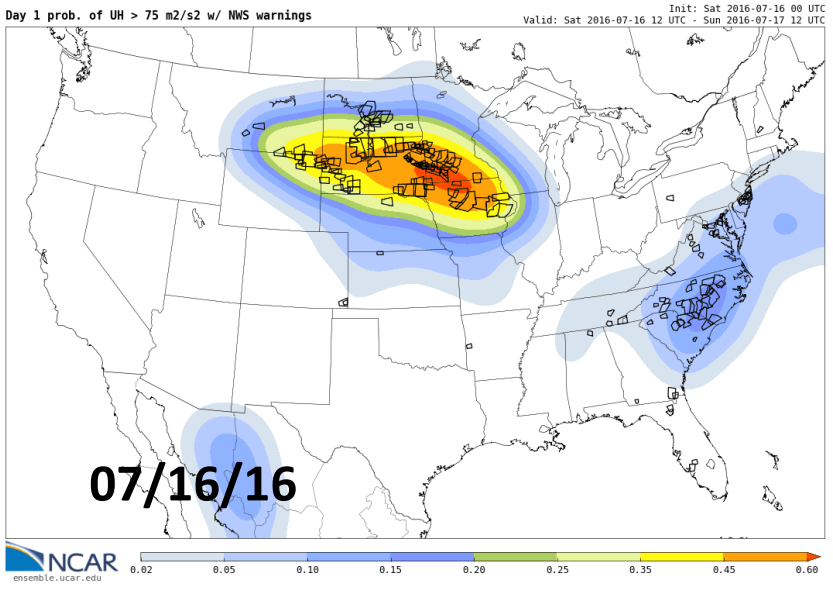
Ensemble Probability of Severe: Updraft Helicity > 75

Derecho-ish Events



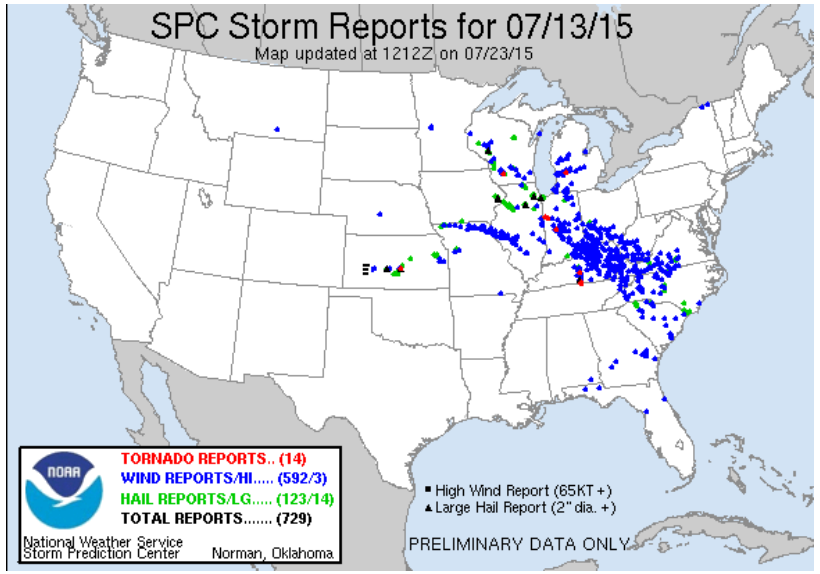


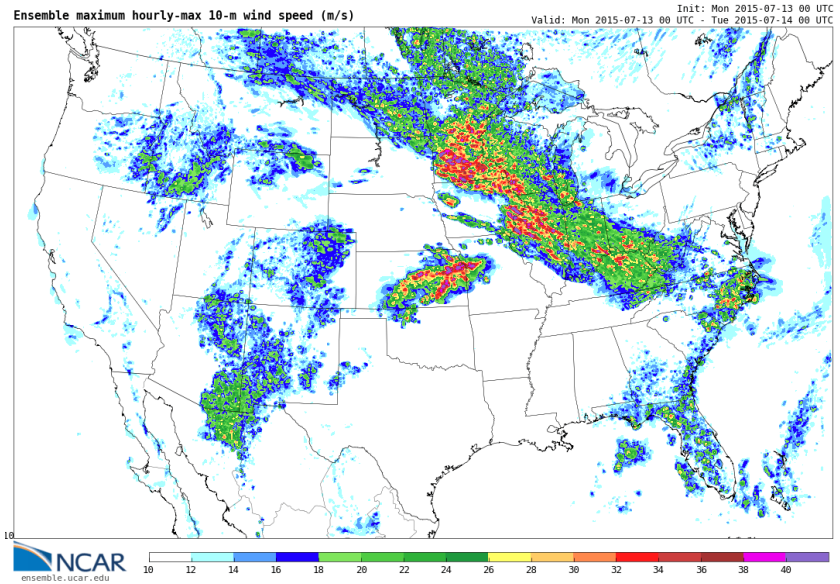




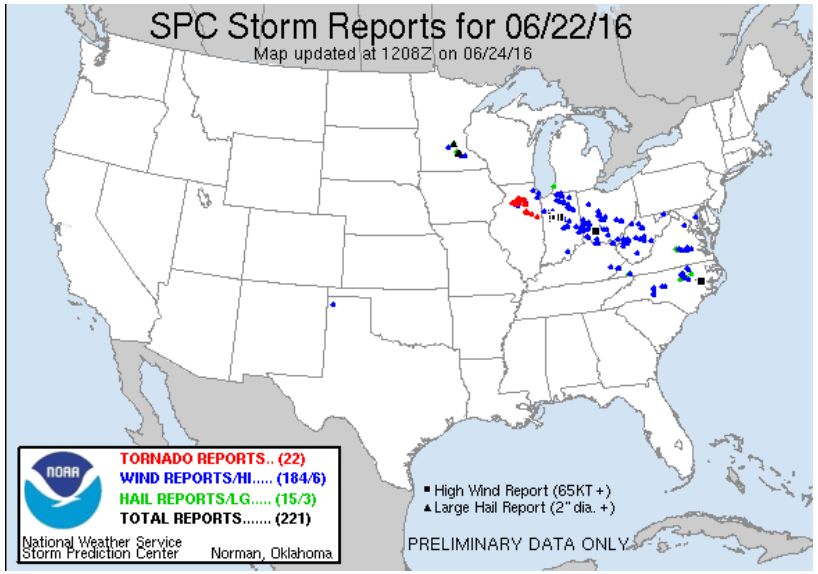
Ensemble Maximum Surface Winds:

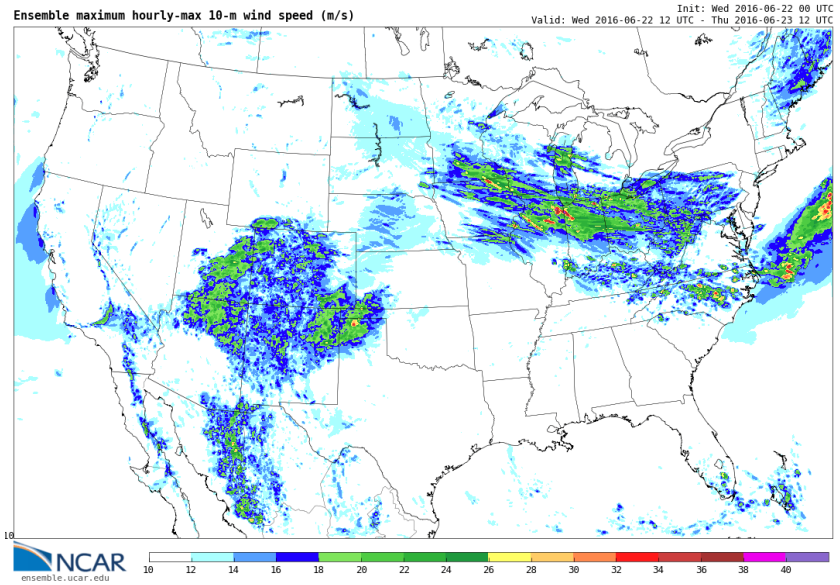
07/13/15





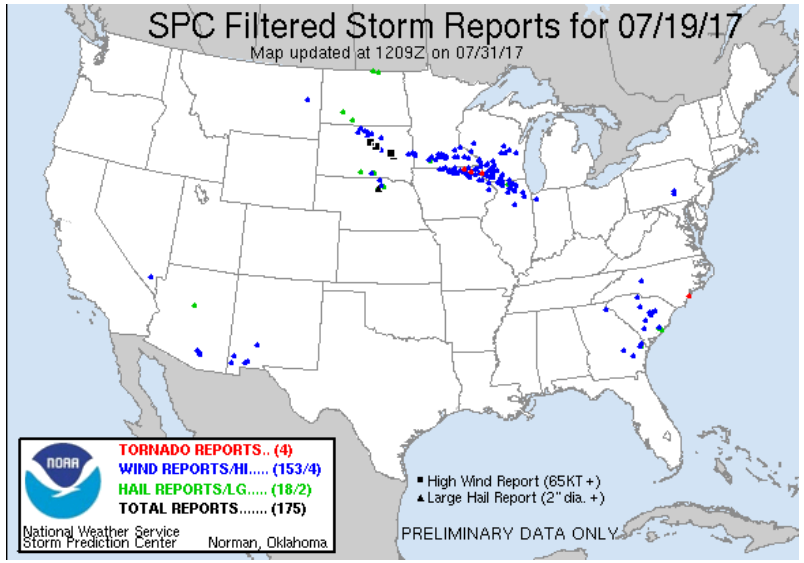
06/22/16

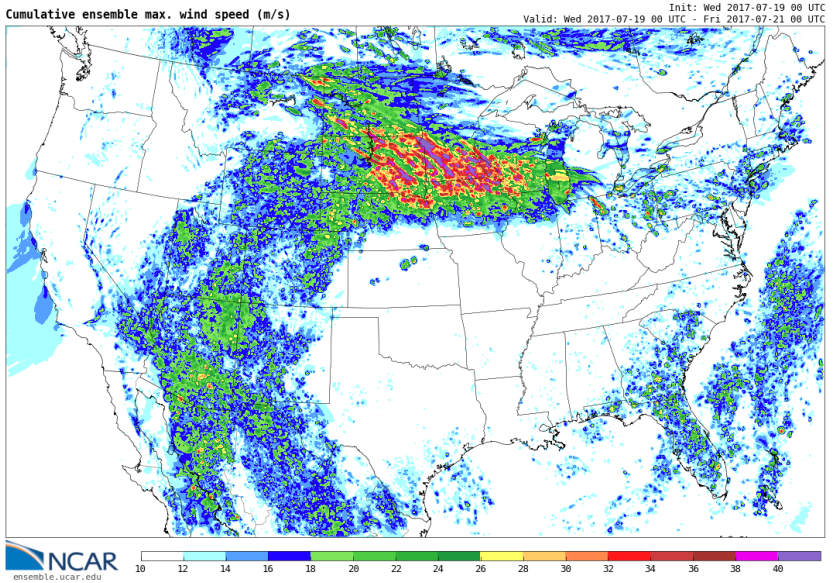




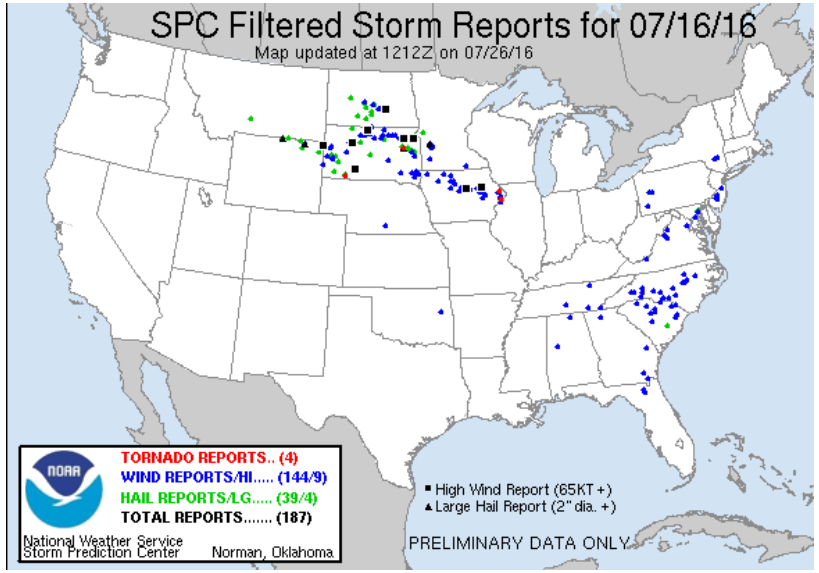
Ensemble Maximum Surface Winds:

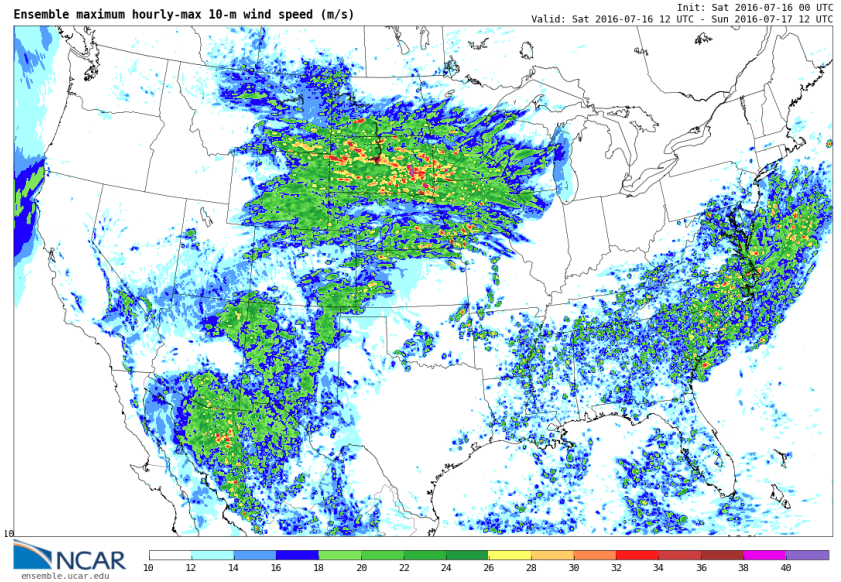
07/19/17



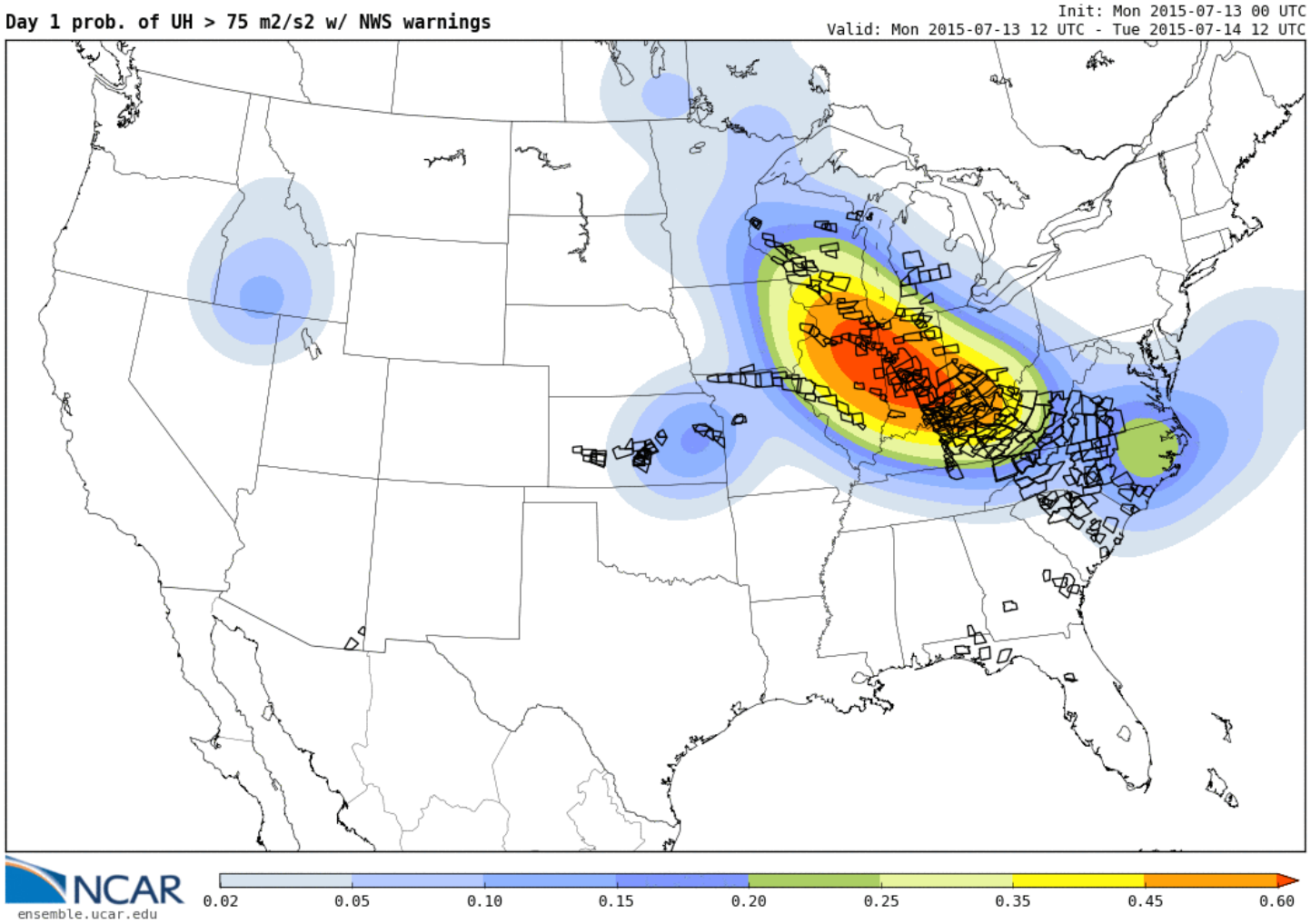


07/16/16





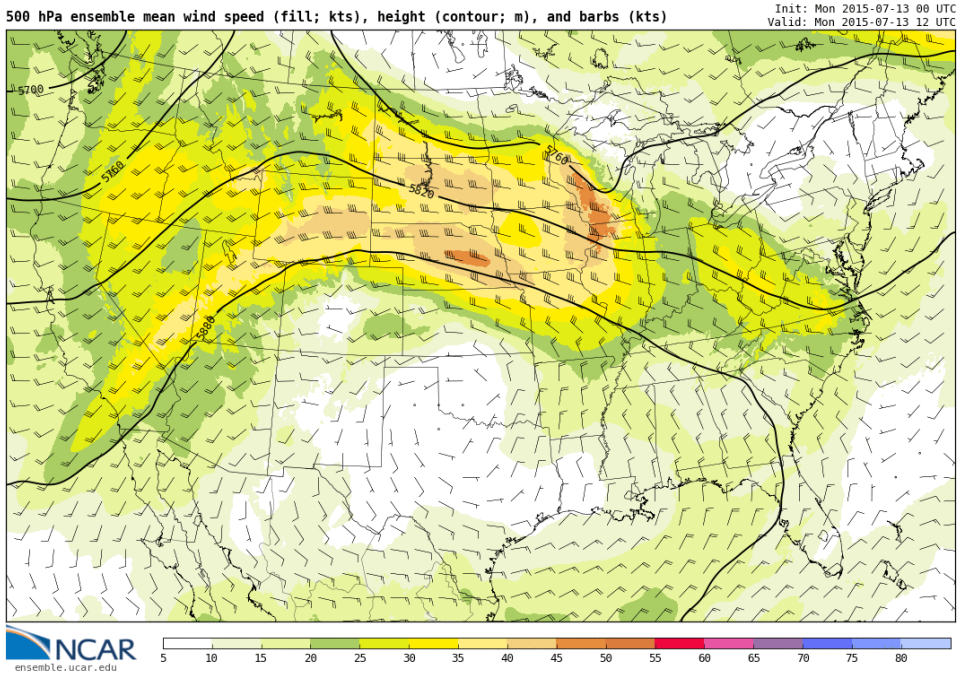
07/13/15


Day 1 prob. of UH > 75 m2/s2 w/ NWS warnings
Init: Mon 2015-07-13 00 UTC
Valid: Mon 2015-07-13 12 UTC - Tue 2015-07-14 12 UTC
NCAR
ensemble.ucar.edu
0.02
0.05
0.10
0.15
0.20
0.25
0.35
0.45
0.60

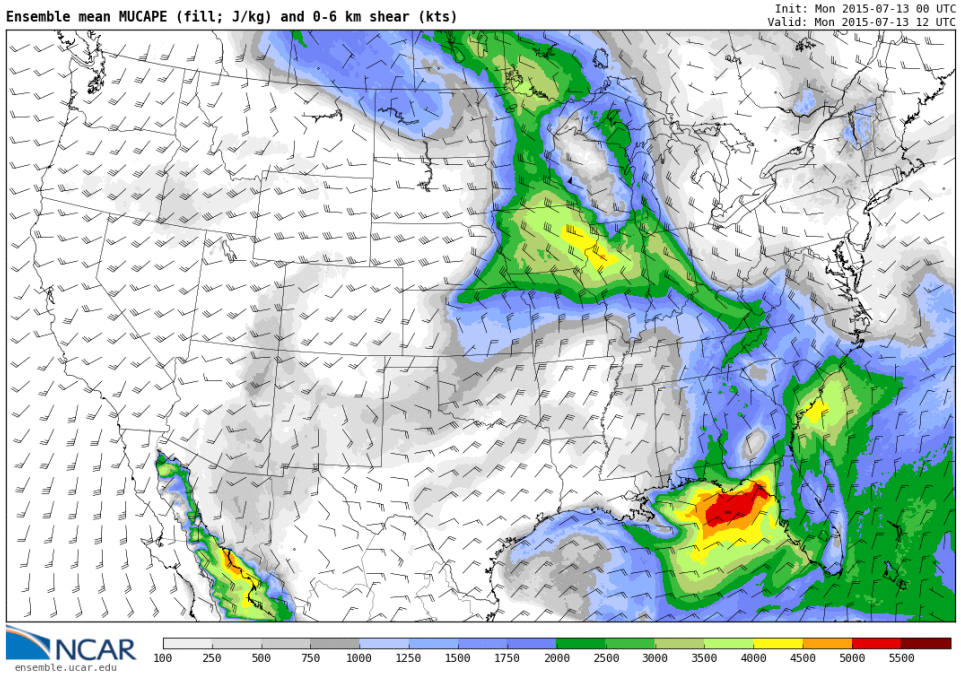
07/13/15

12 UTC

500 hPa

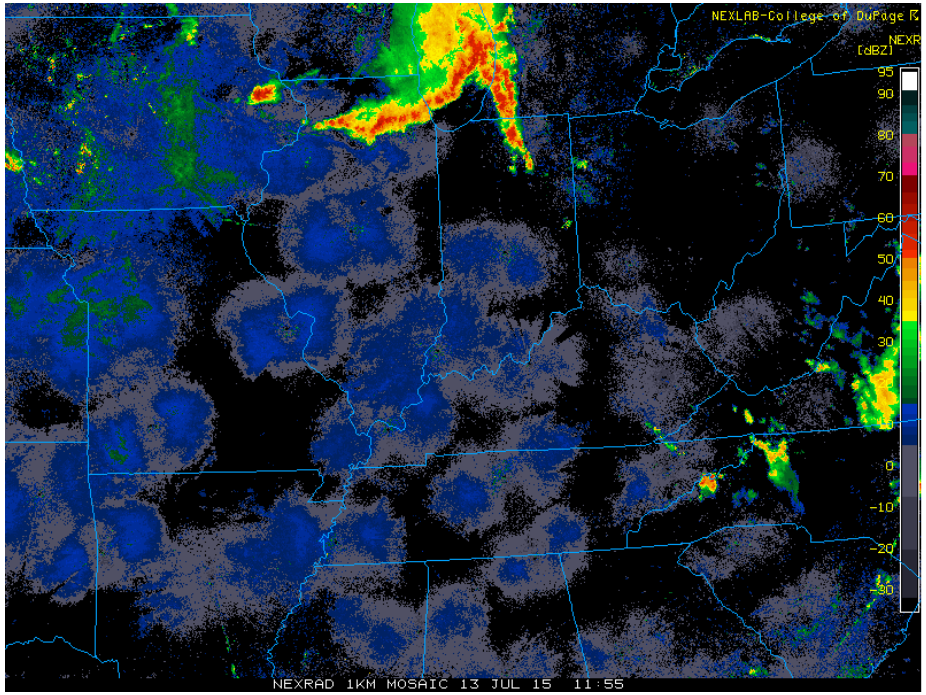


Ensemble-mean MUCAPE/6 km shear

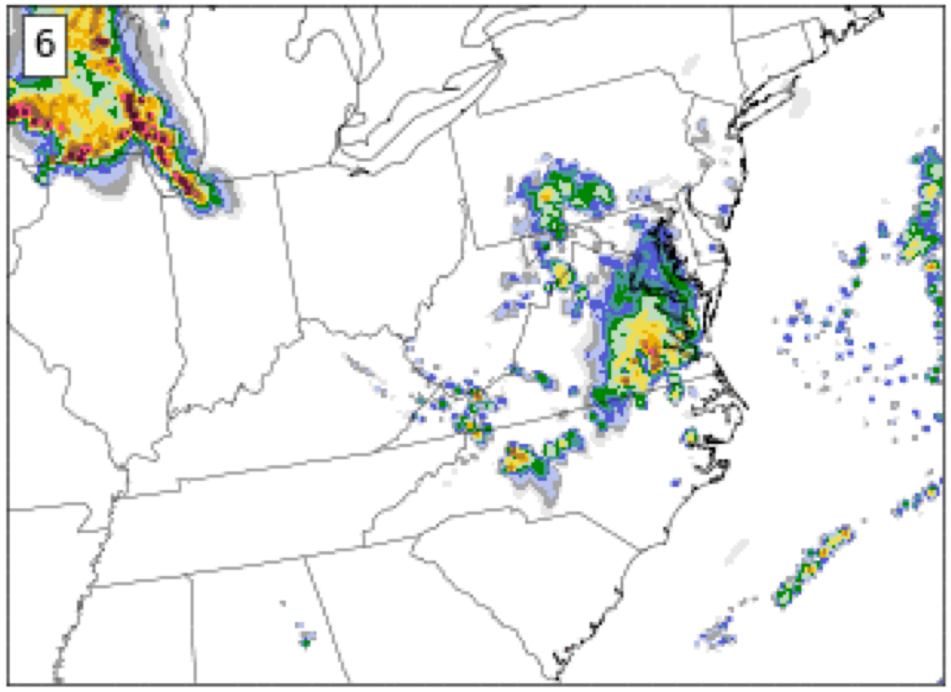


13 July 2015

Radar



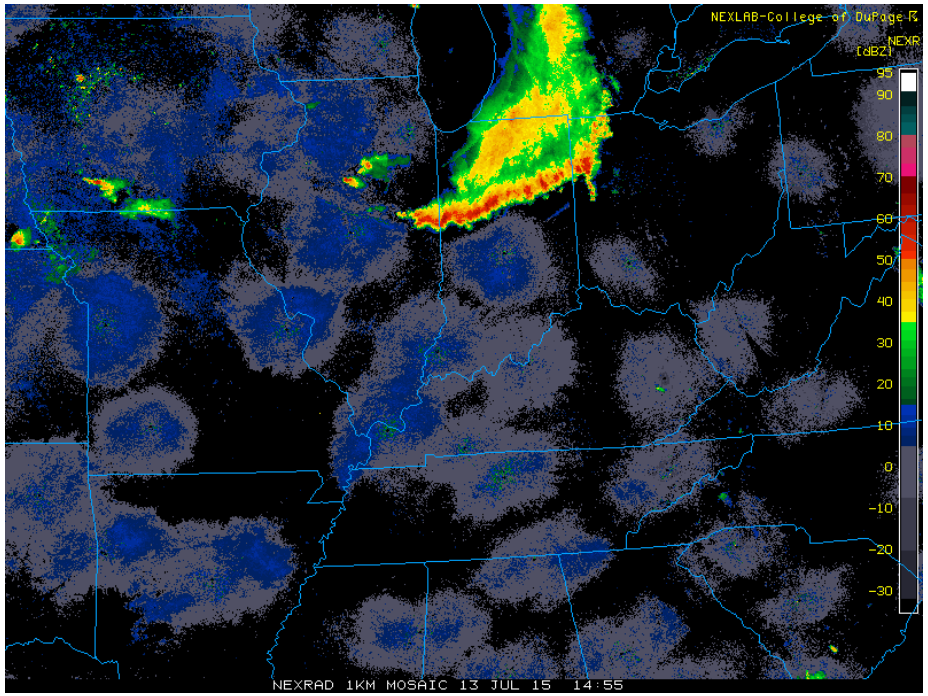
Model Reflectivity 12h



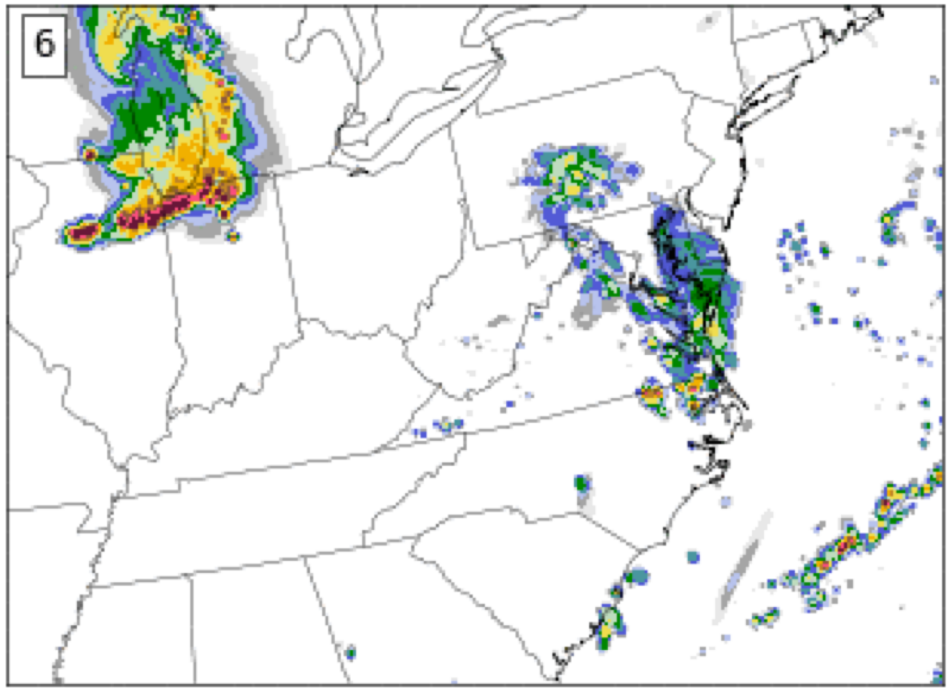
12:00 UTC

13 July 2015

Radar



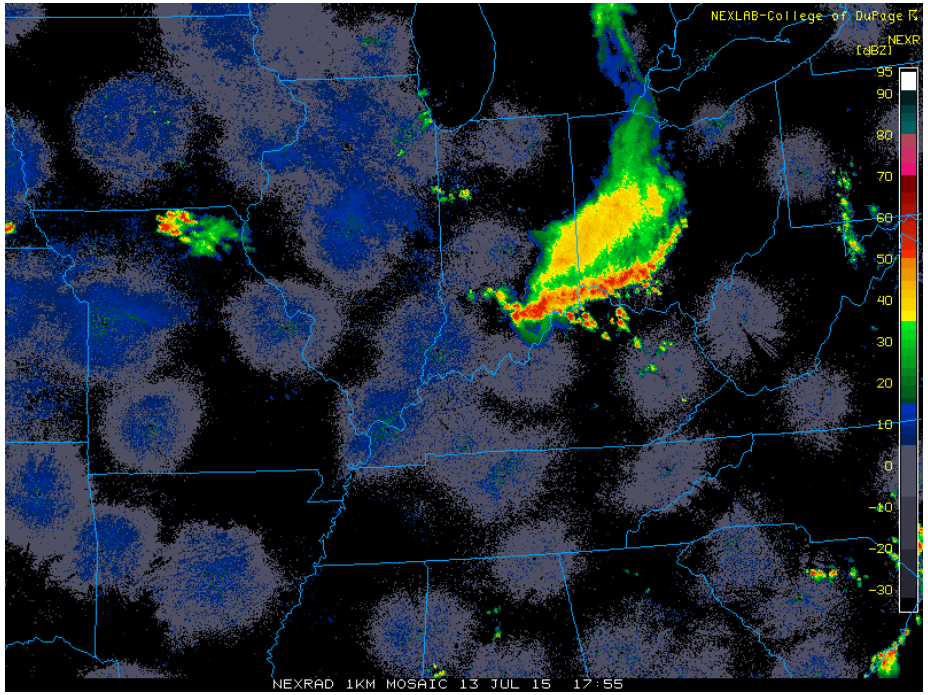
Model Reflectivity 15h



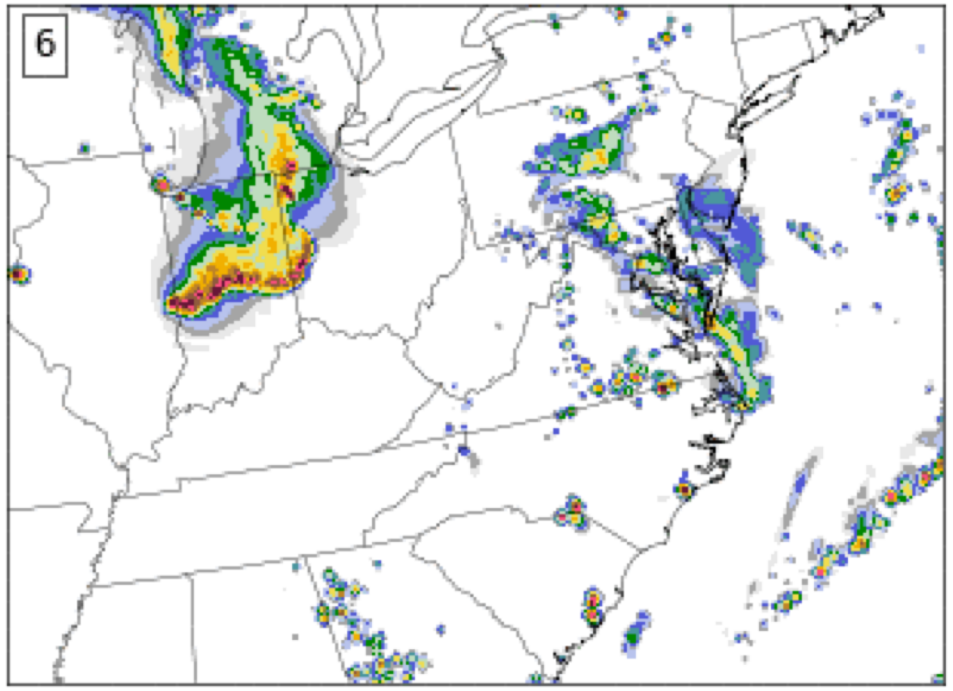
15:00 UTC

13 July 2015

Radar



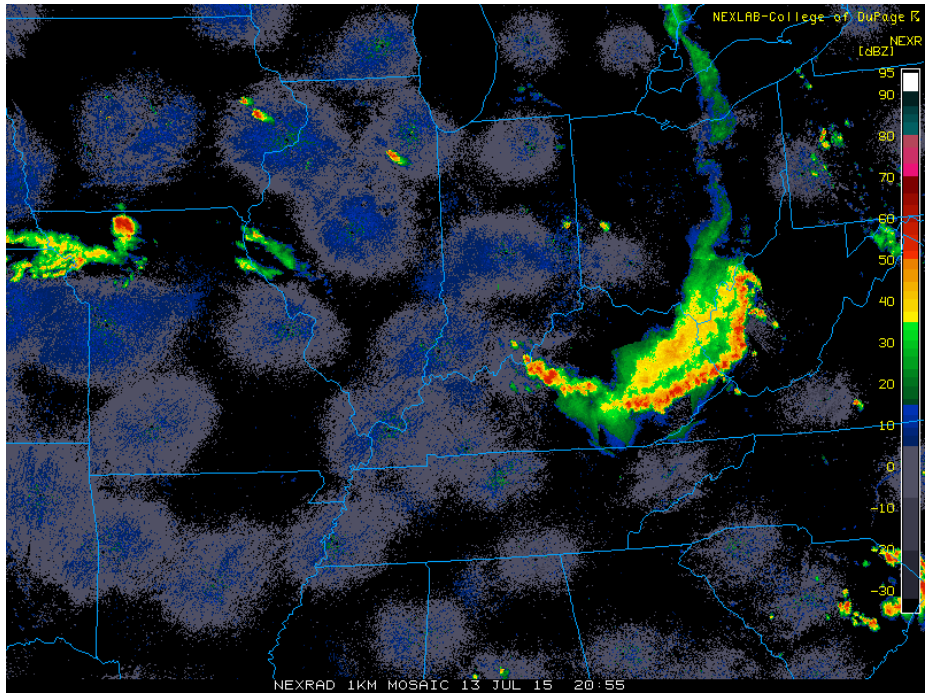
Model Reflectivity 18h



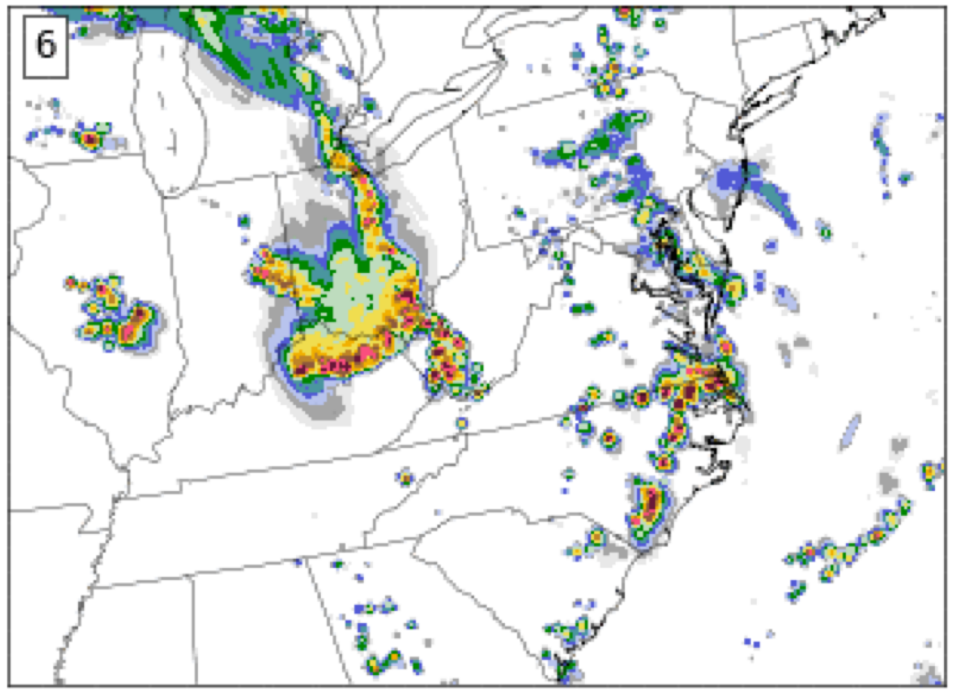
18:00 UTC

13 July 2015

Radar



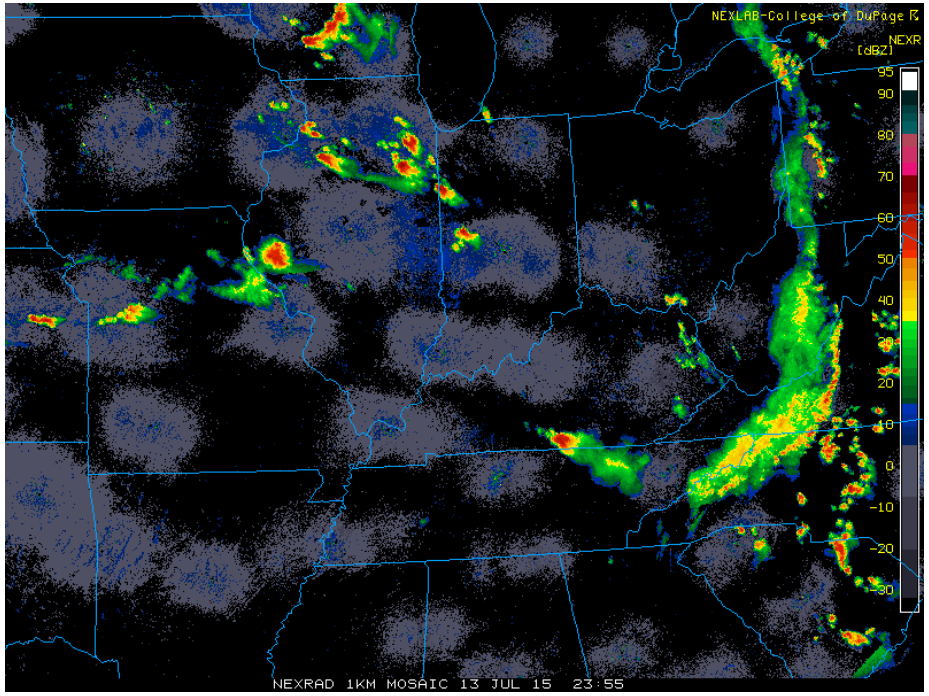
Model Reflectivity 21h



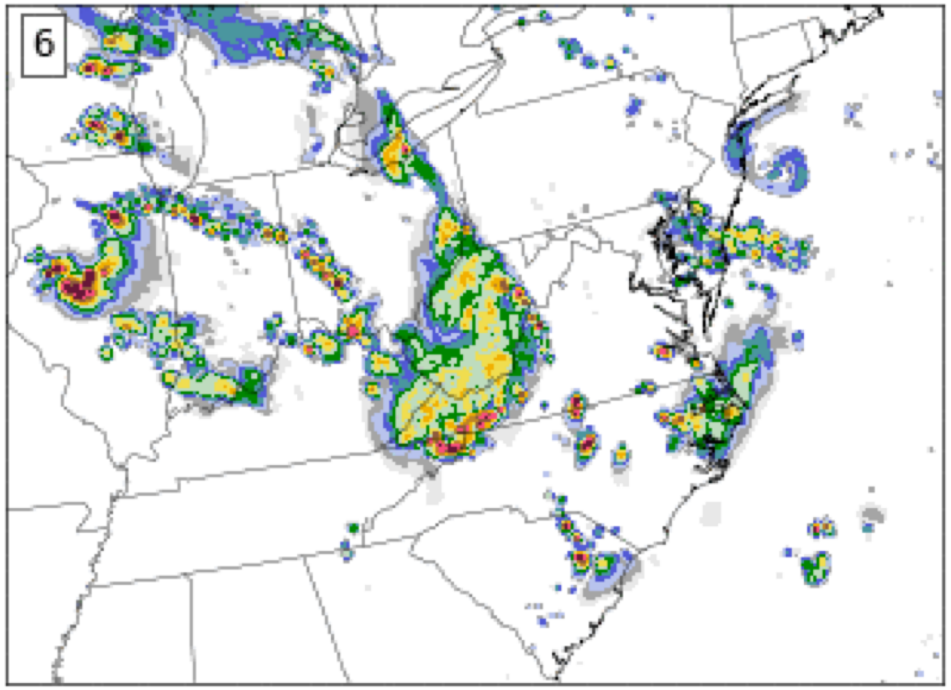
21:00 UTC

13 July 2015

Radar



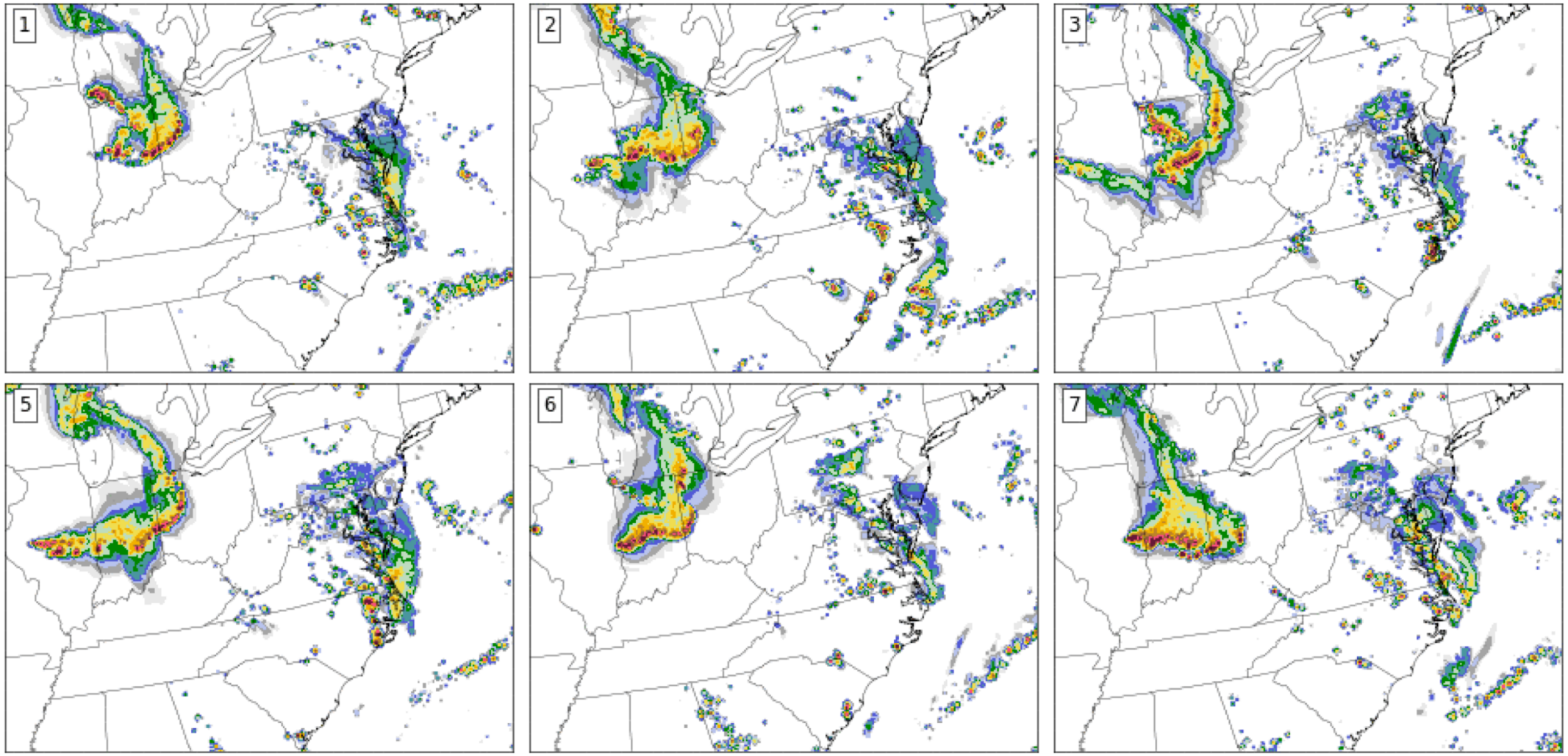
Model Reflectivity 24h



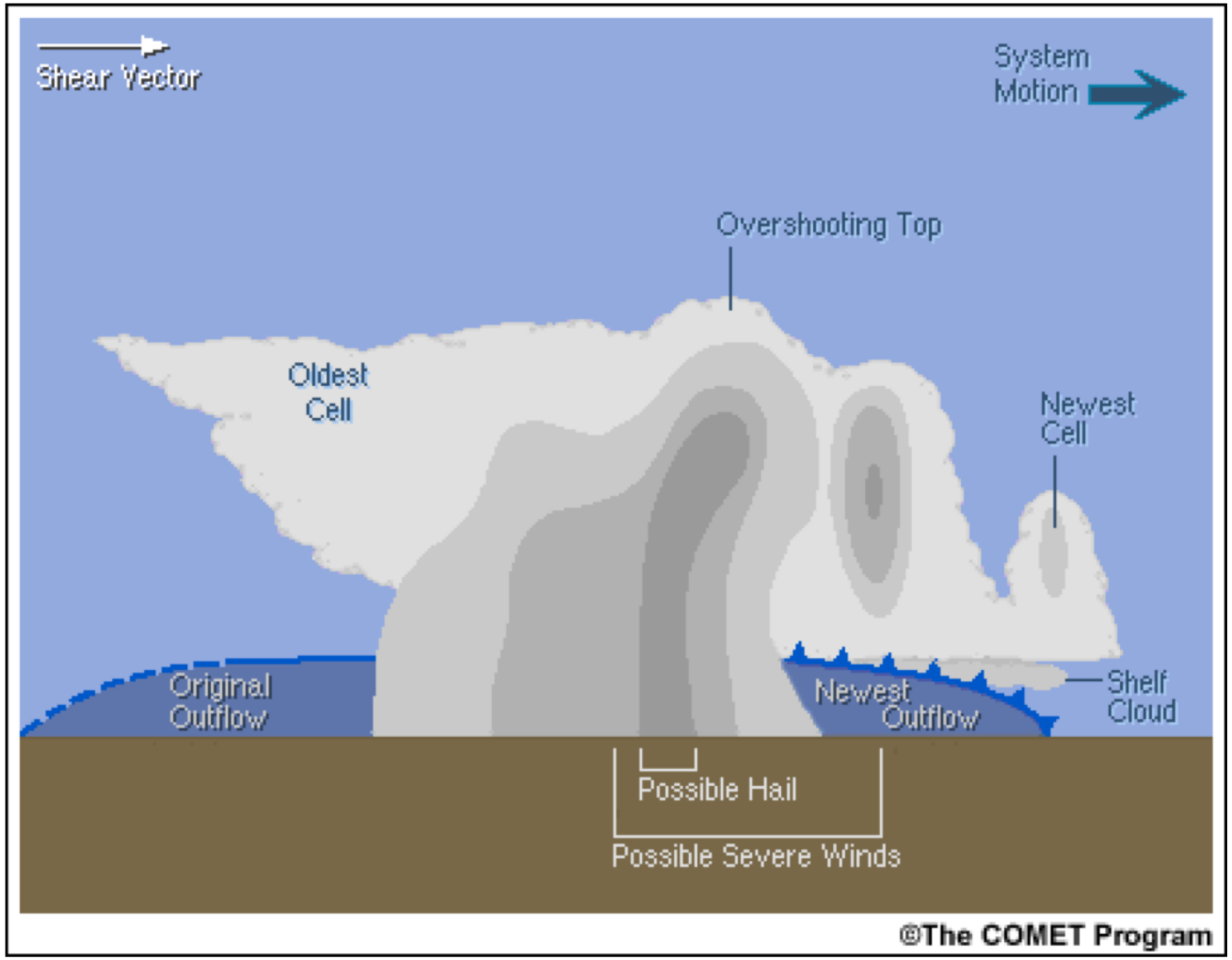
00:00 UTC

13 July 2015

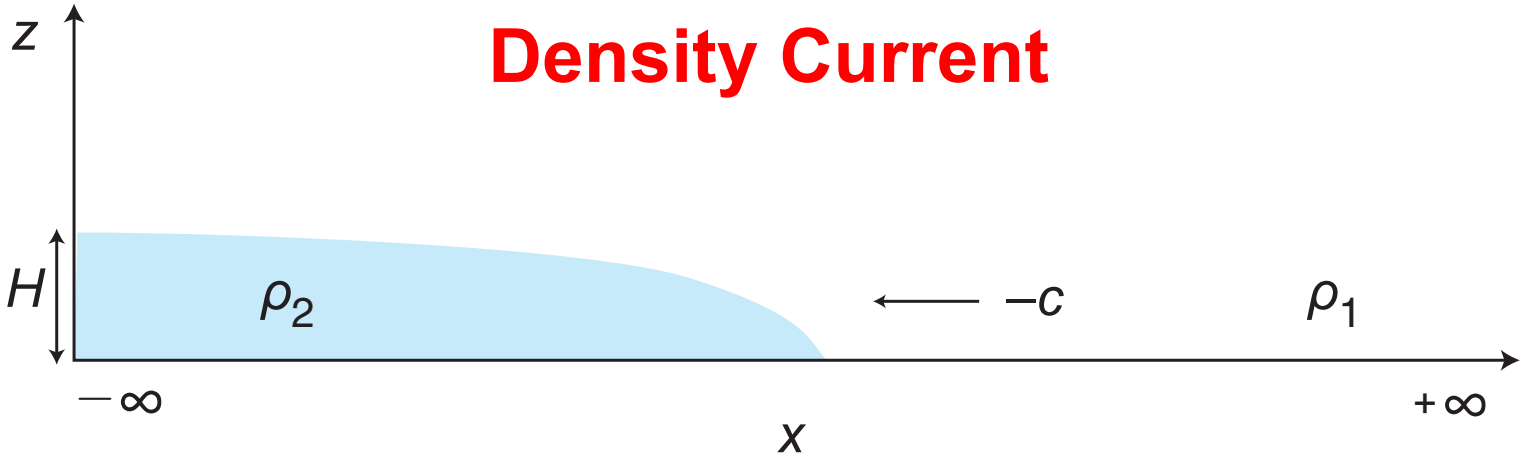
18 h forecast 6 Ensemble Members



Cold pool is critical for cell regeneration and system propagation:



Density Current



Theoretical speed of propagation:

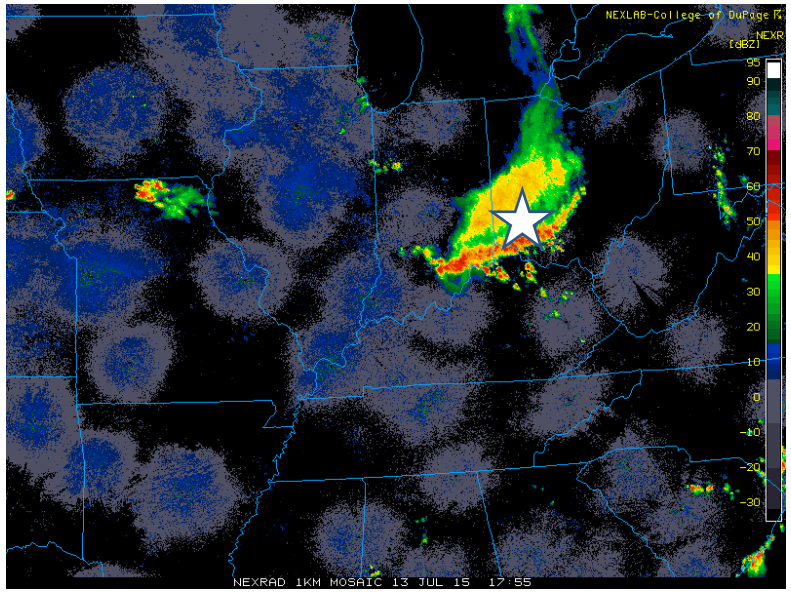
$$c^2 = 2\int_o^H \left(-B\right) dz \qquad B \equiv -g\frac{\rho'}{\bar{\rho}} \equiv g\frac{\theta'}{\bar{\theta}}$$

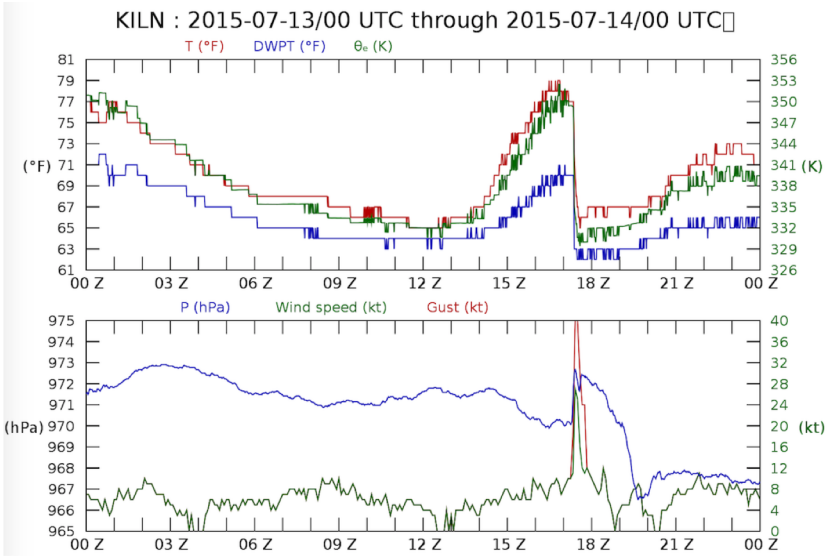
$$c = \sqrt{2g\frac{\bar{\theta}'}{\bar{\theta}}H} = \sqrt{2\frac{\Delta P}{\bar{\rho}}}$$

Strength of a cold pool can be estimated from change in surface T, Theta, P….

13 July 2015

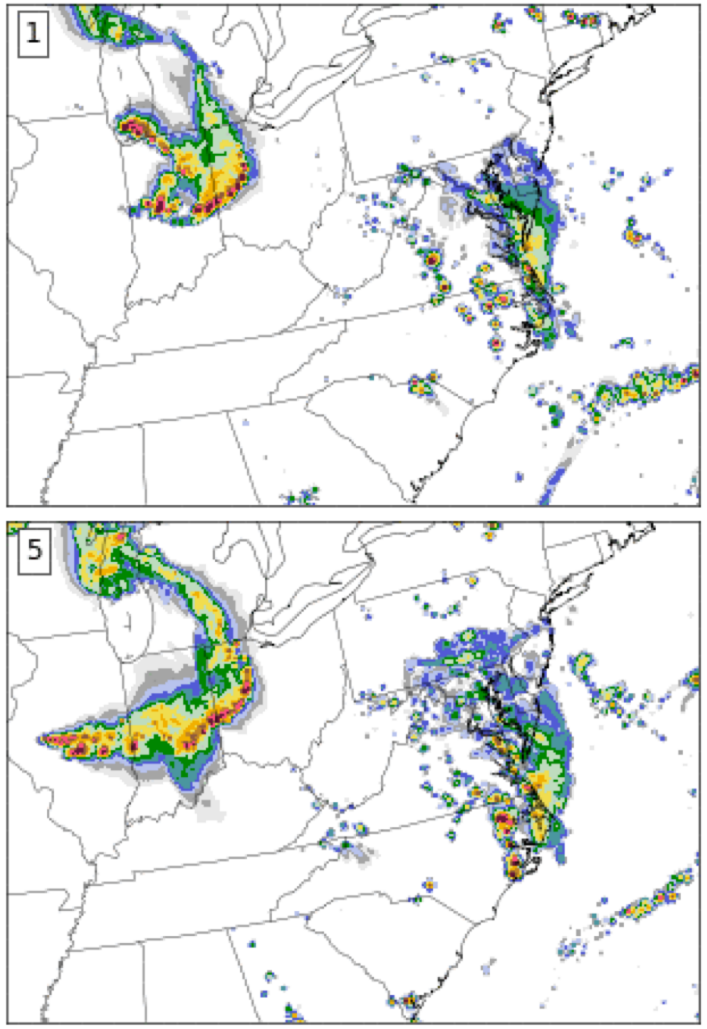
Reflectivity 18 UTC





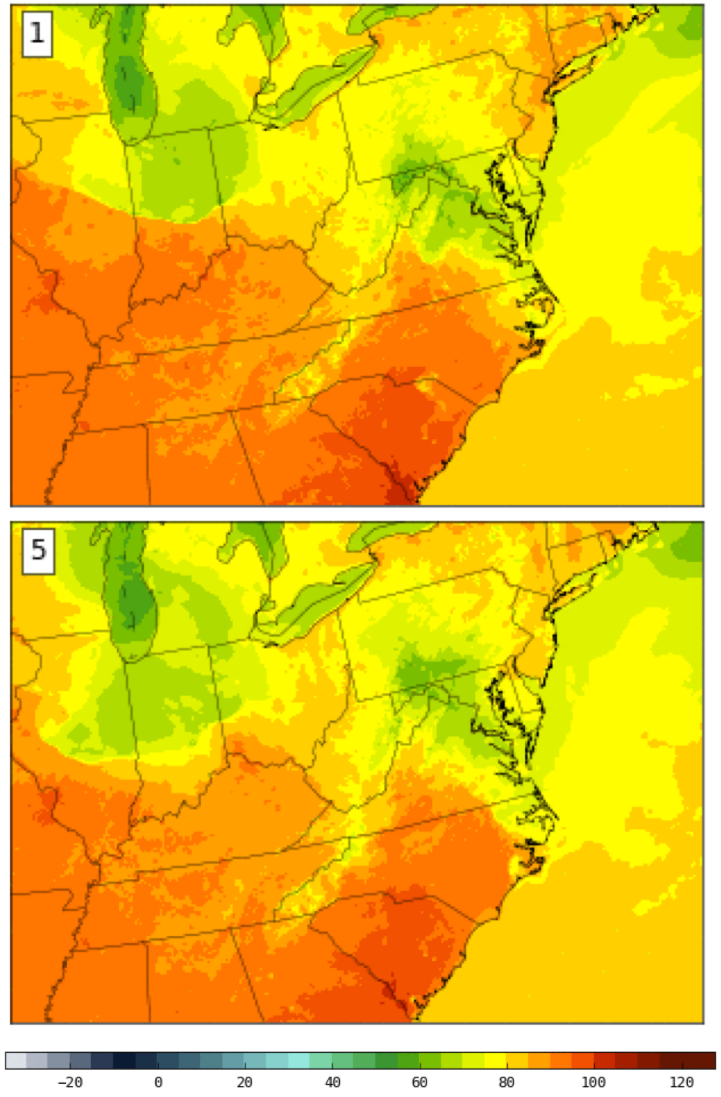
Cold Pool ~13 F

Ensemble Reflectivity 18 UTC



System propagation too slow?

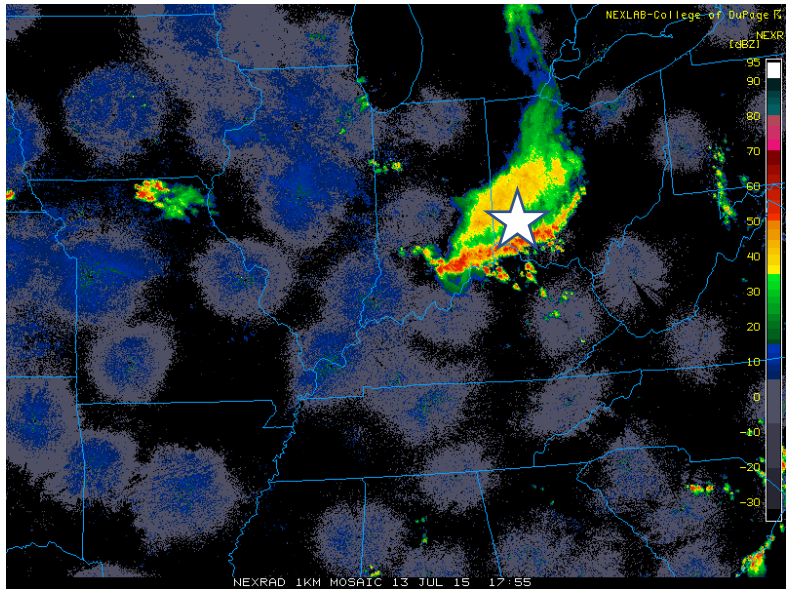
Ensemble Surface T 18 UTC

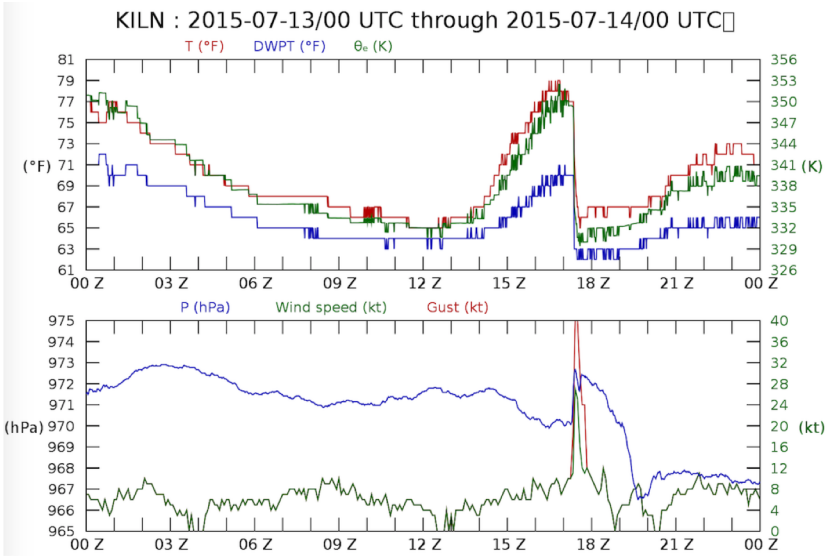


Ensemble Cold Pool ~15 F

13 July 2015

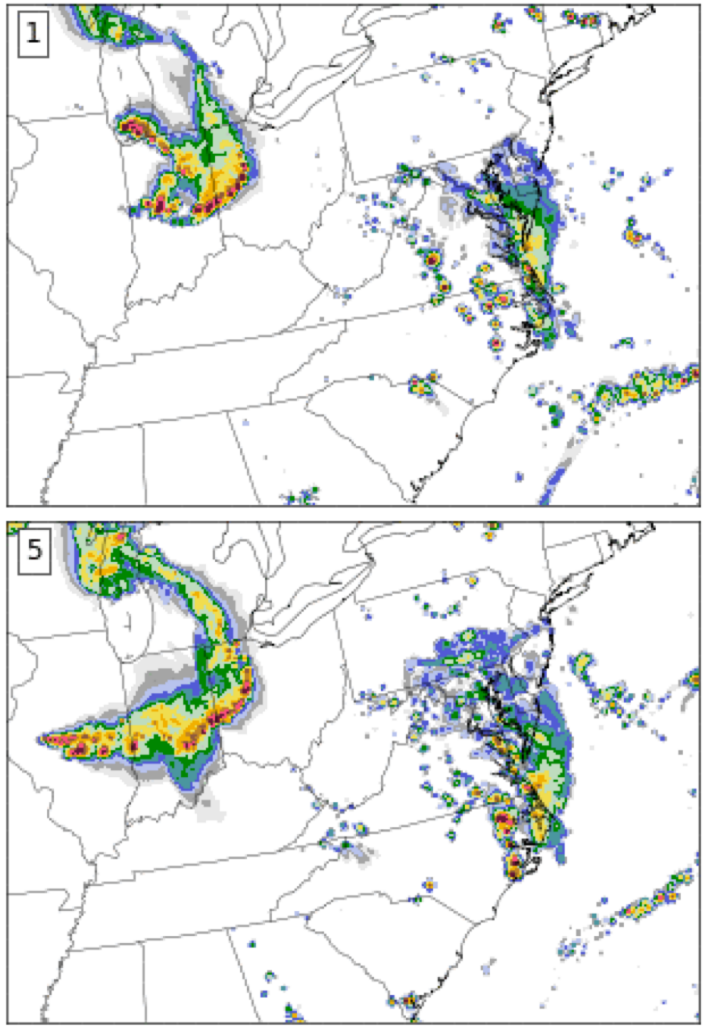
Reflectivity 18 UTC



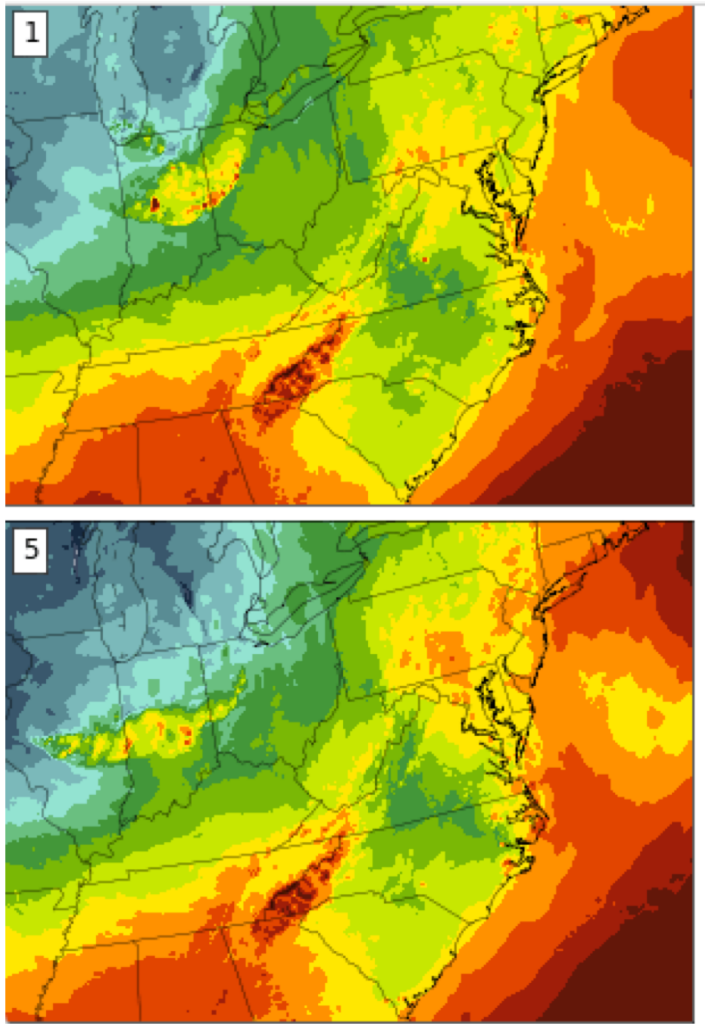


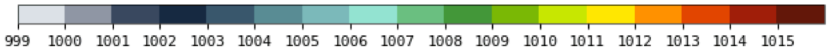
Cold Pool ~3 hPa

Ensemble Reflectivity 18 UTC



Ensemble Surface P 18 UTC



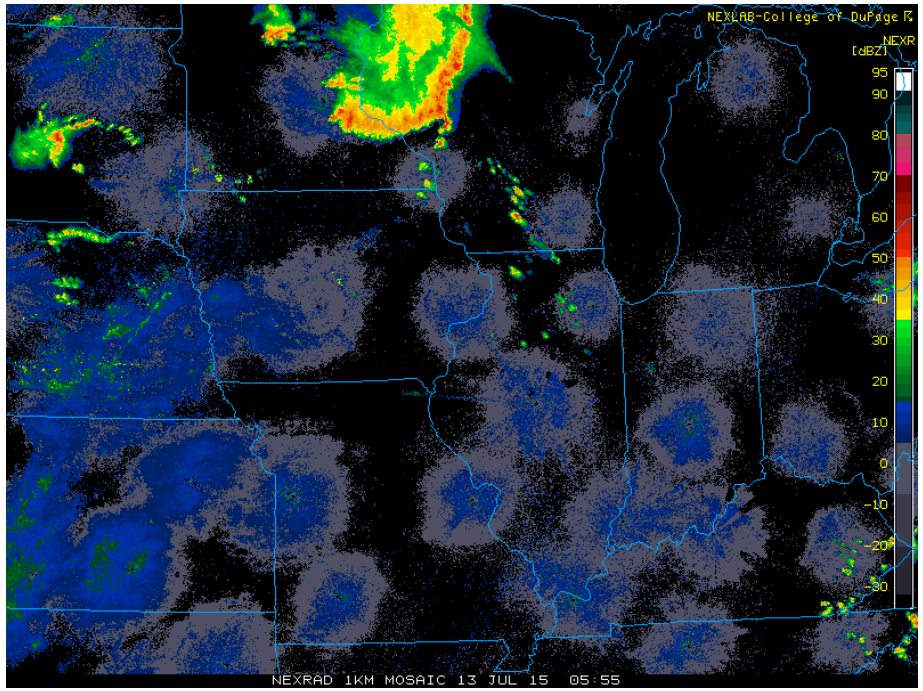


System propagation too slow?

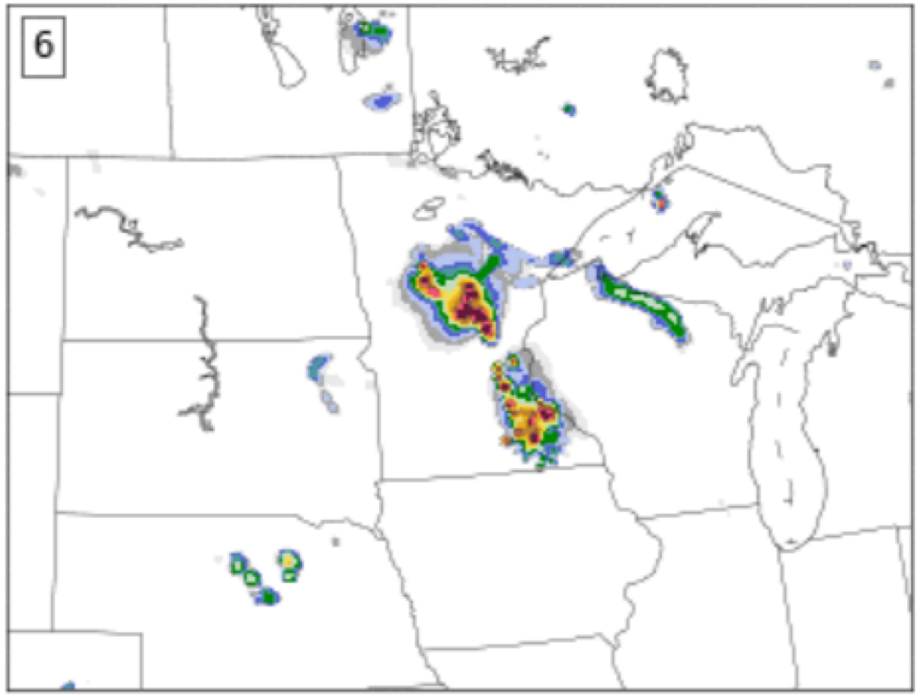
Ensemble Cold Pool ~4 hPa

13 July 2015

Radar



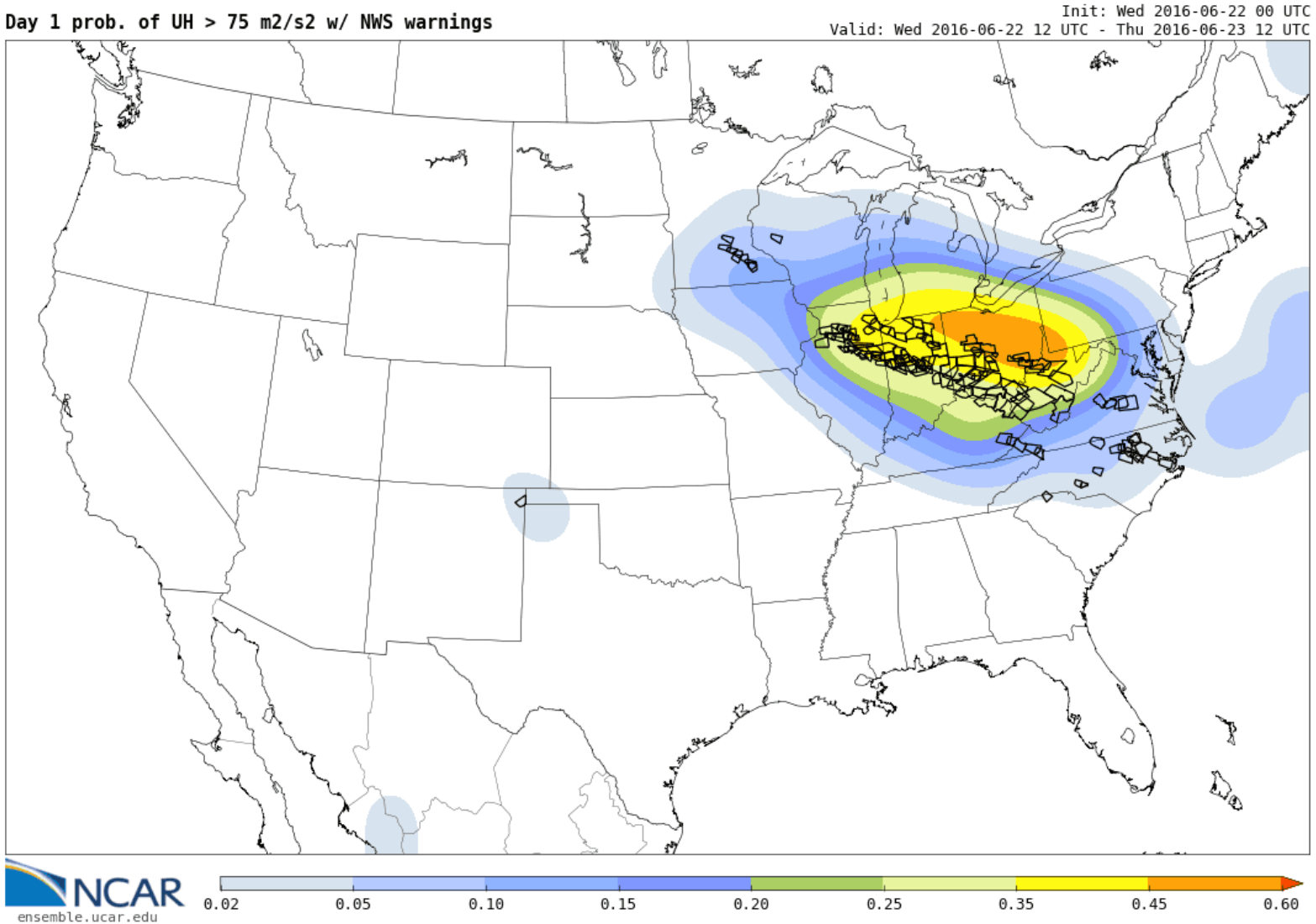
Model Reflectivity 06h



06:00 UTC

Modeled convective mode wrong during early stages…

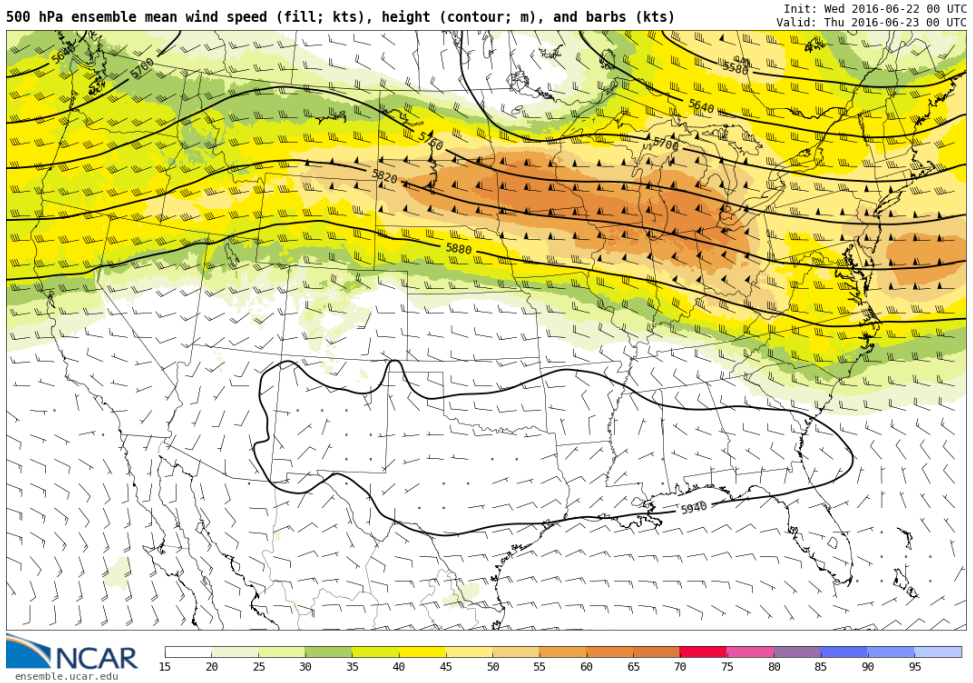
22-23 June 2016



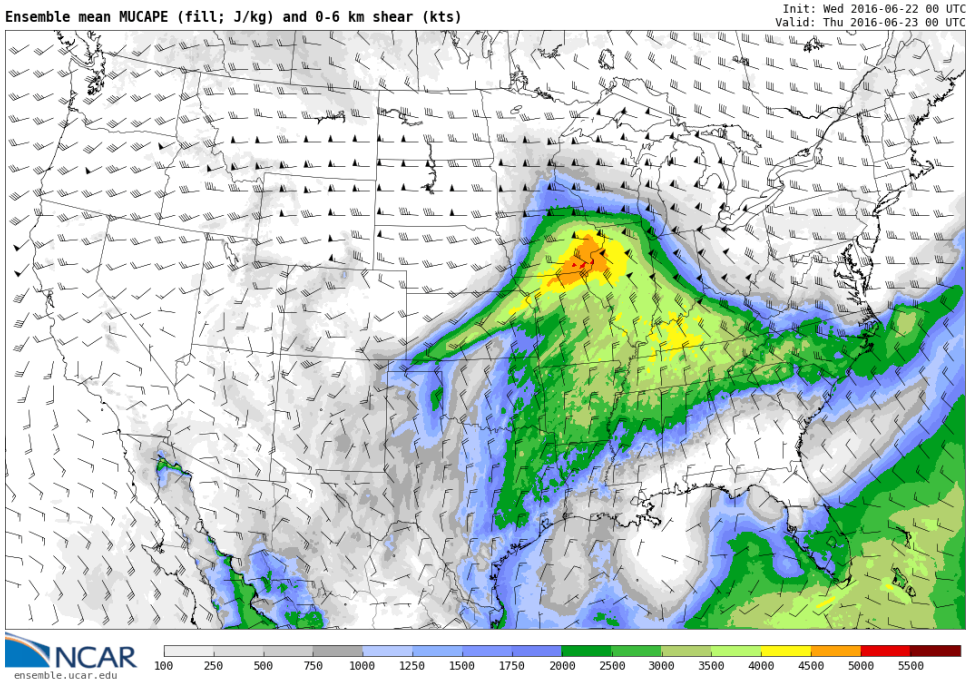
06/22/16

06/23 00 UTC

500 hPa

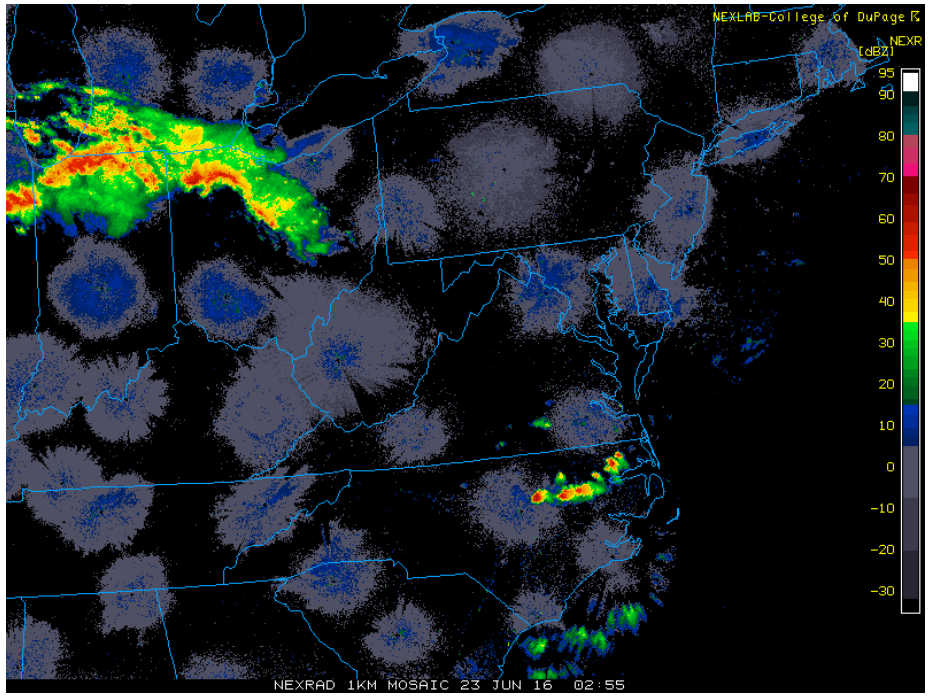


Ensemble-mean MUCAPE/6 km shear

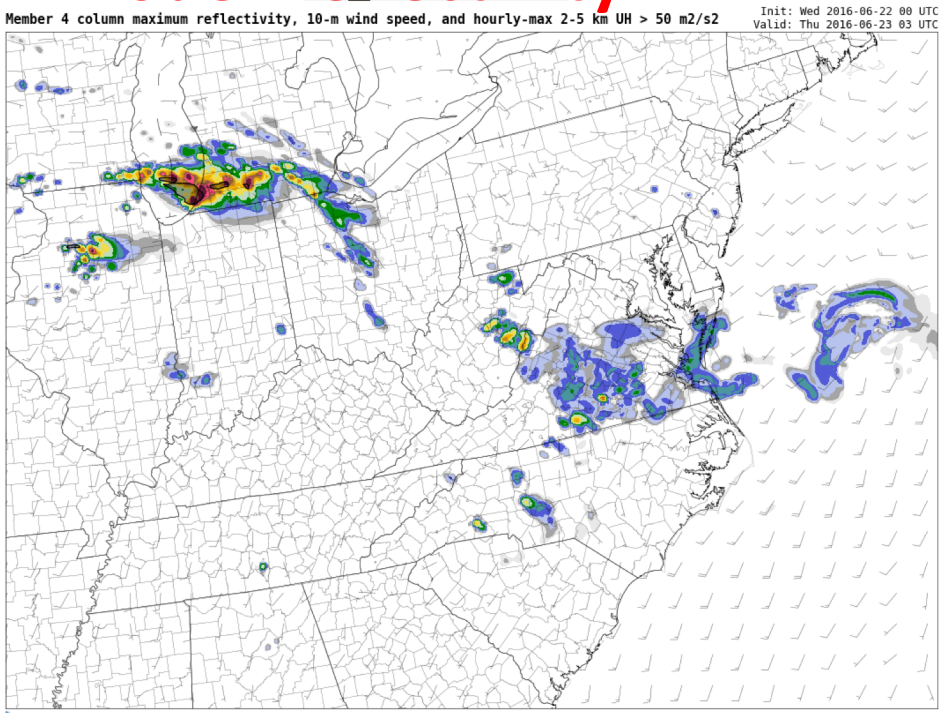


23 June 2016

Radar



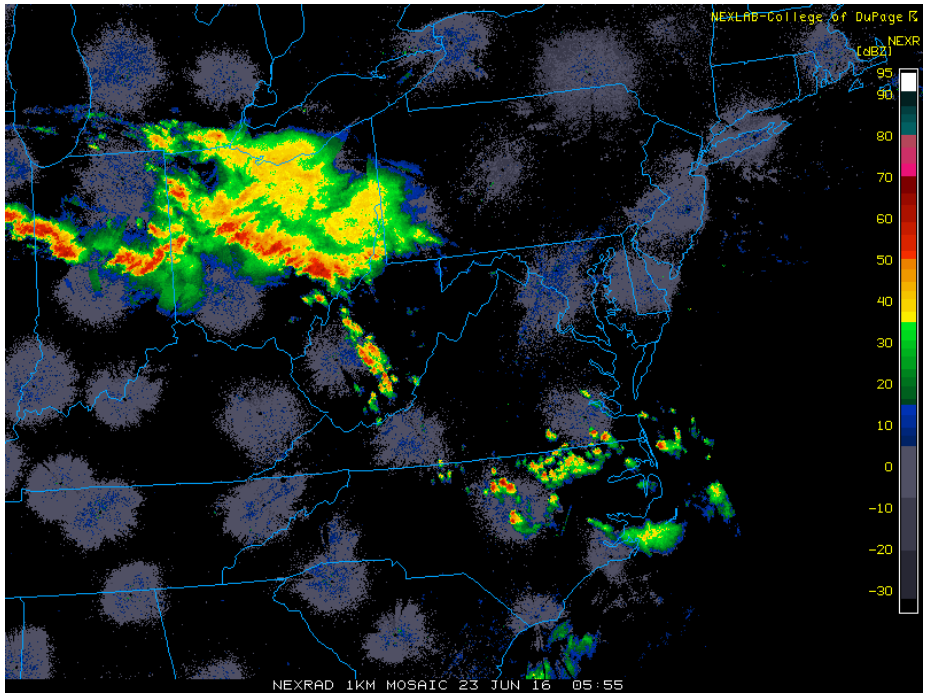
Model Reflectivity 27h



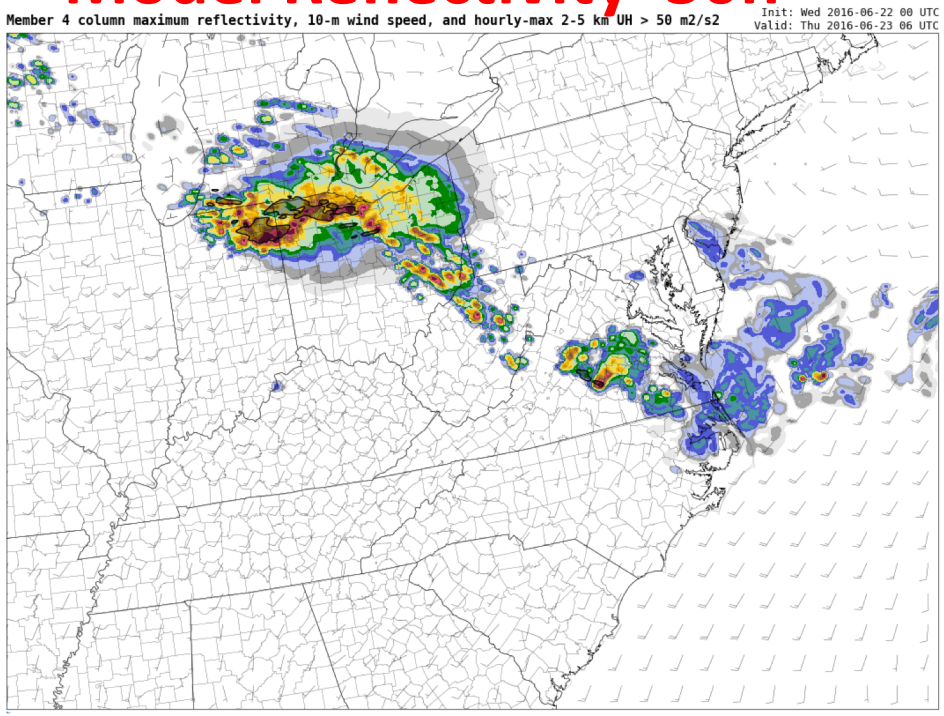
03:00 UTC

23 June 2016

Radar



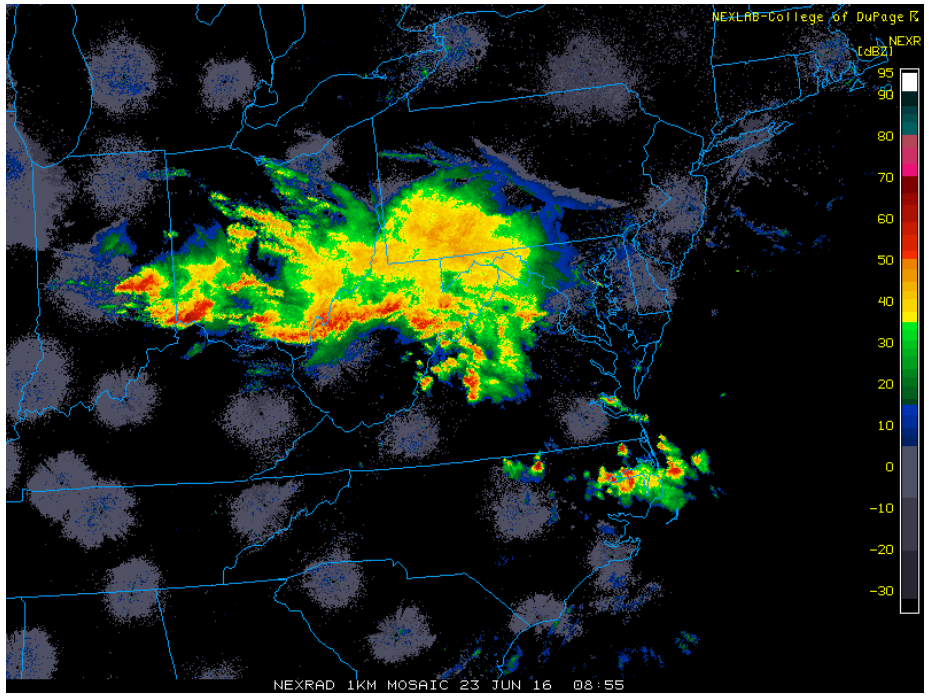
Model Reflectivity 30h



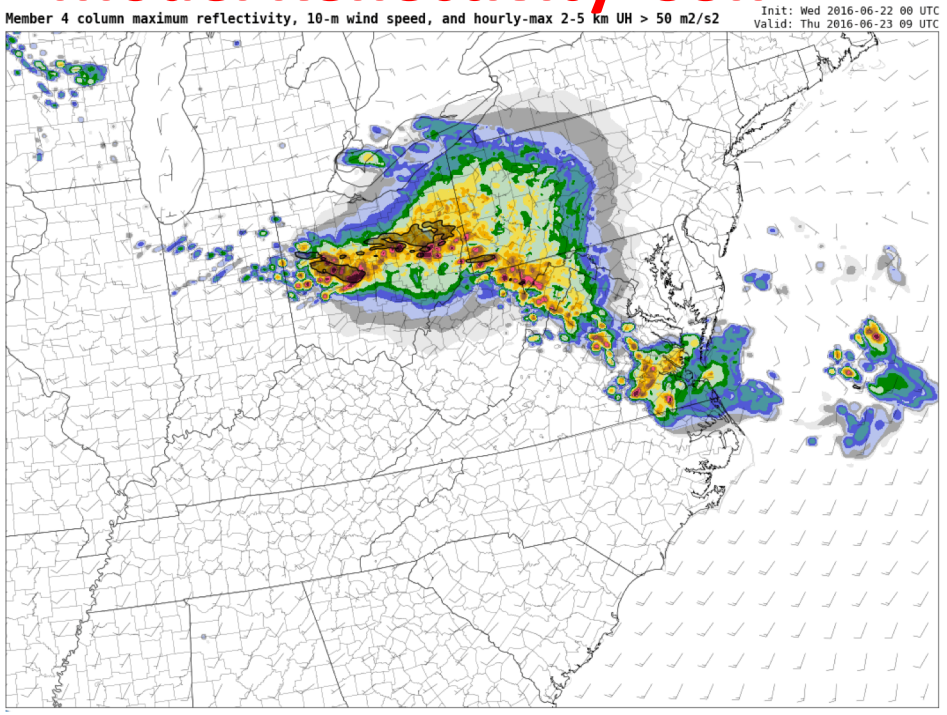
06:00 UTC

23 June 2016

Radar



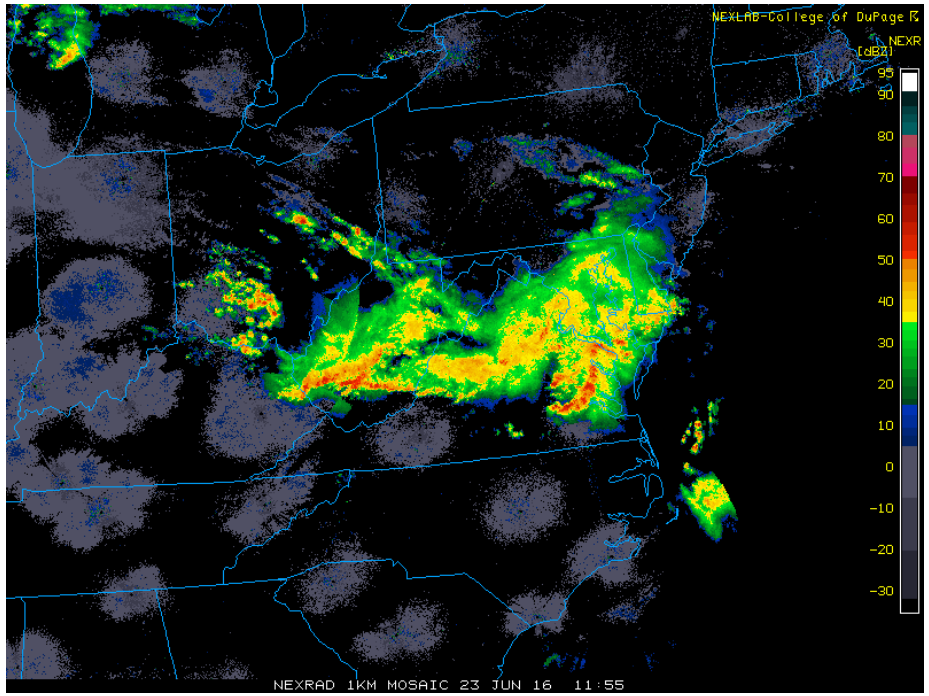
Model Reflectivity 33h



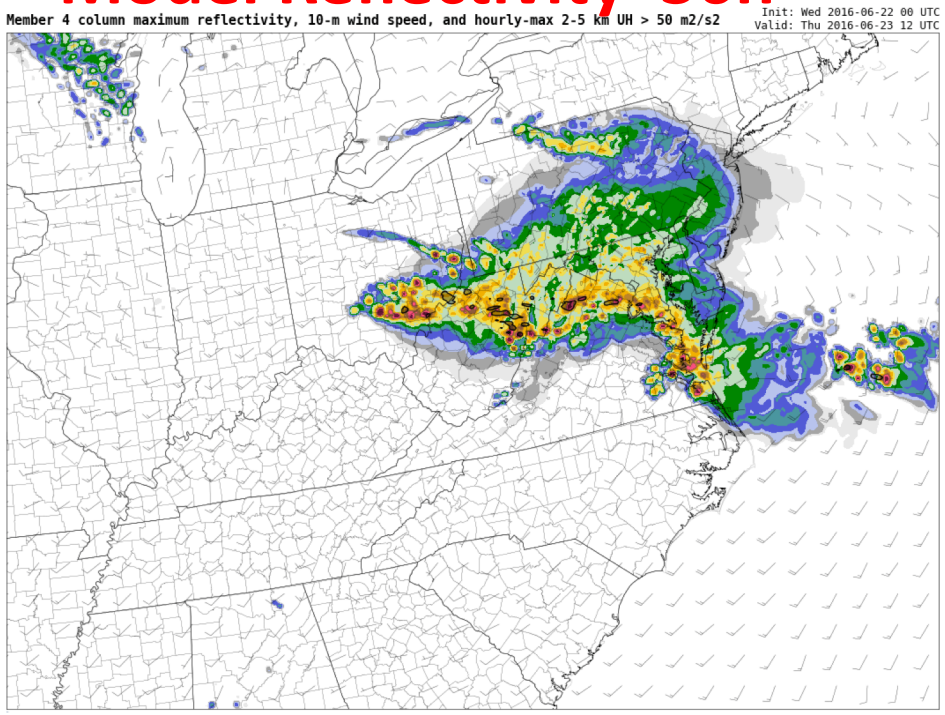
09:00 UTC

23 June 2016

Radar



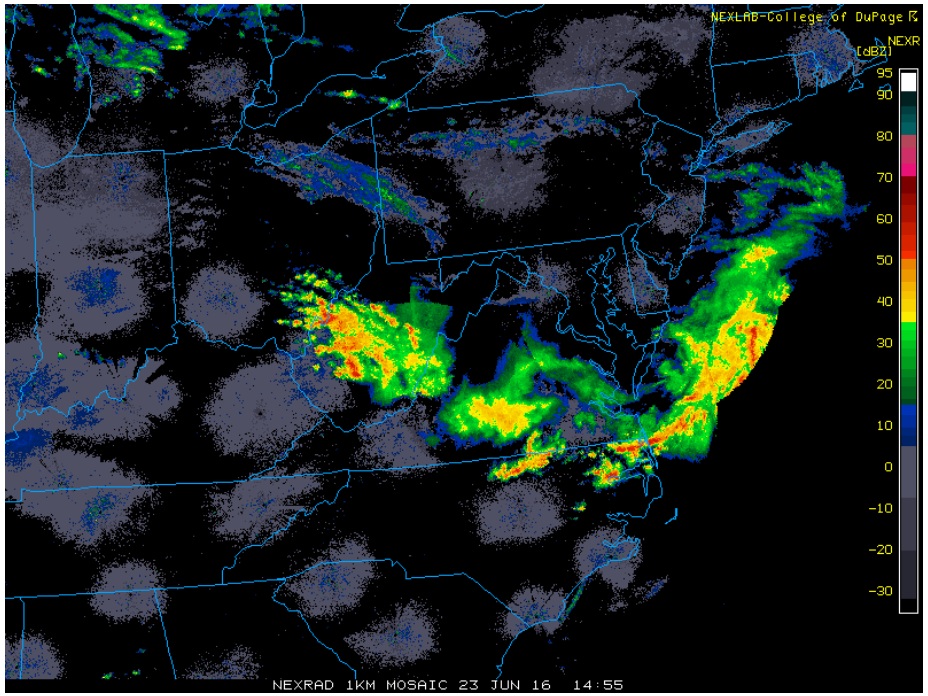
Model Reflectivity 36h



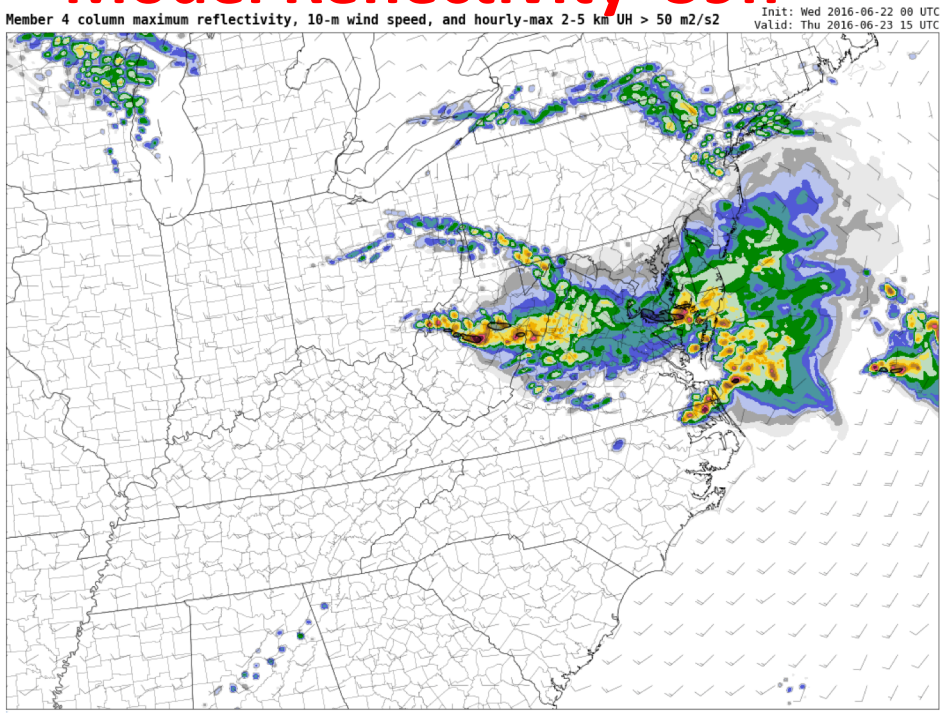
12:00 UTC

23 June 2016

Radar



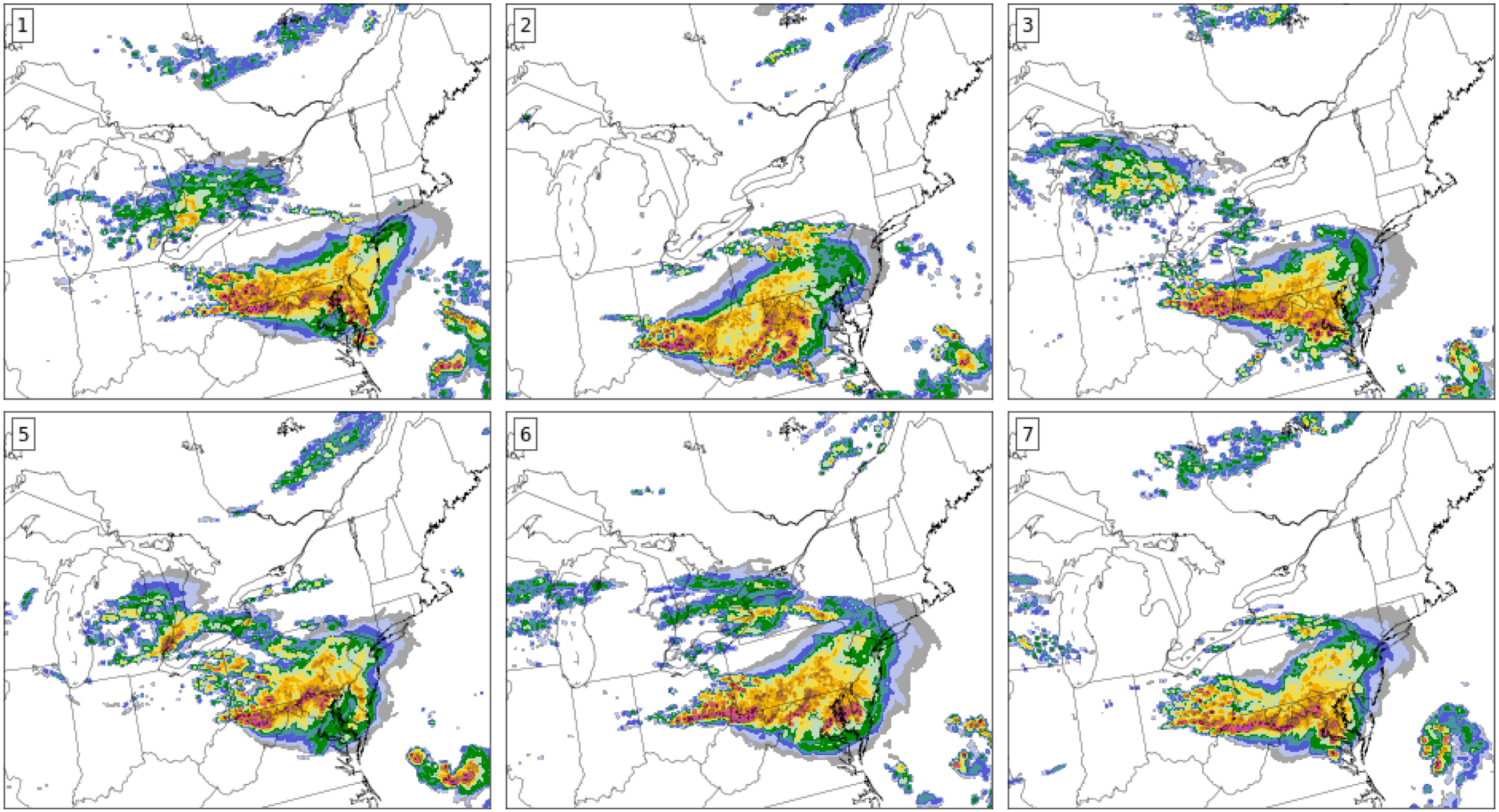
Model Reflectivity 39h



15:00 UTC

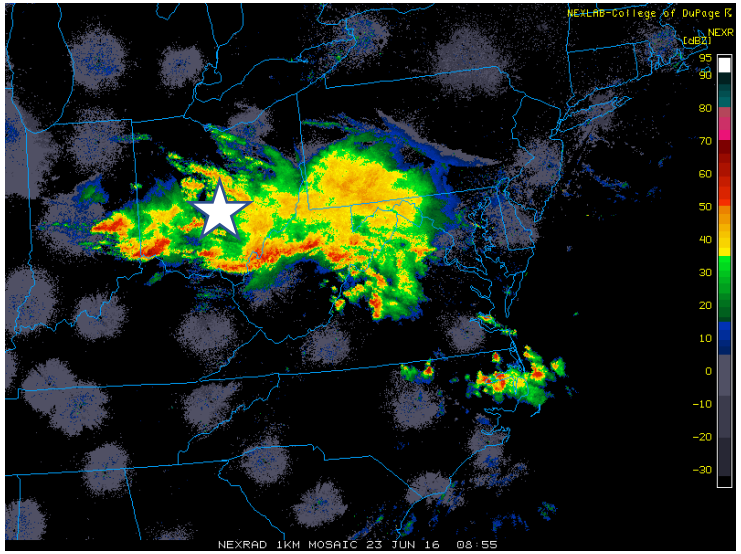
23 June 2016

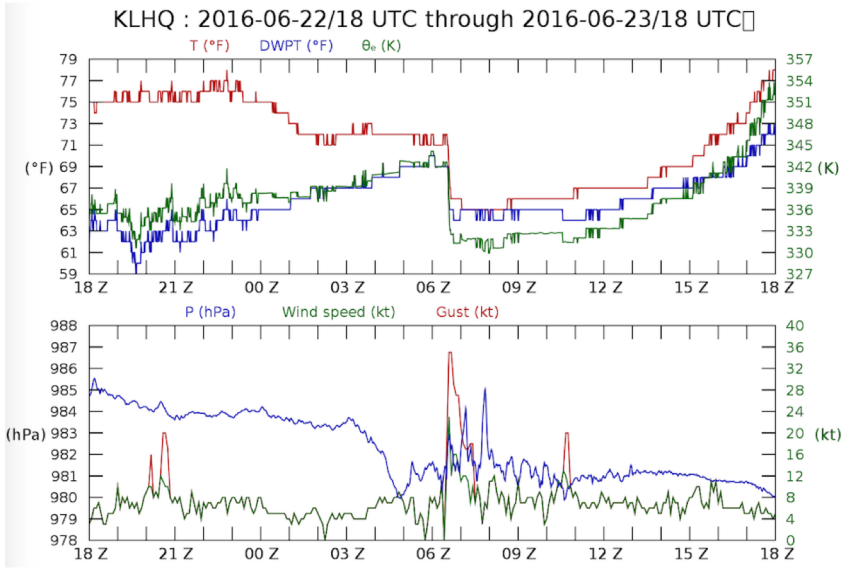
36 h forecast 6 Ensemble Members



23 June 2016

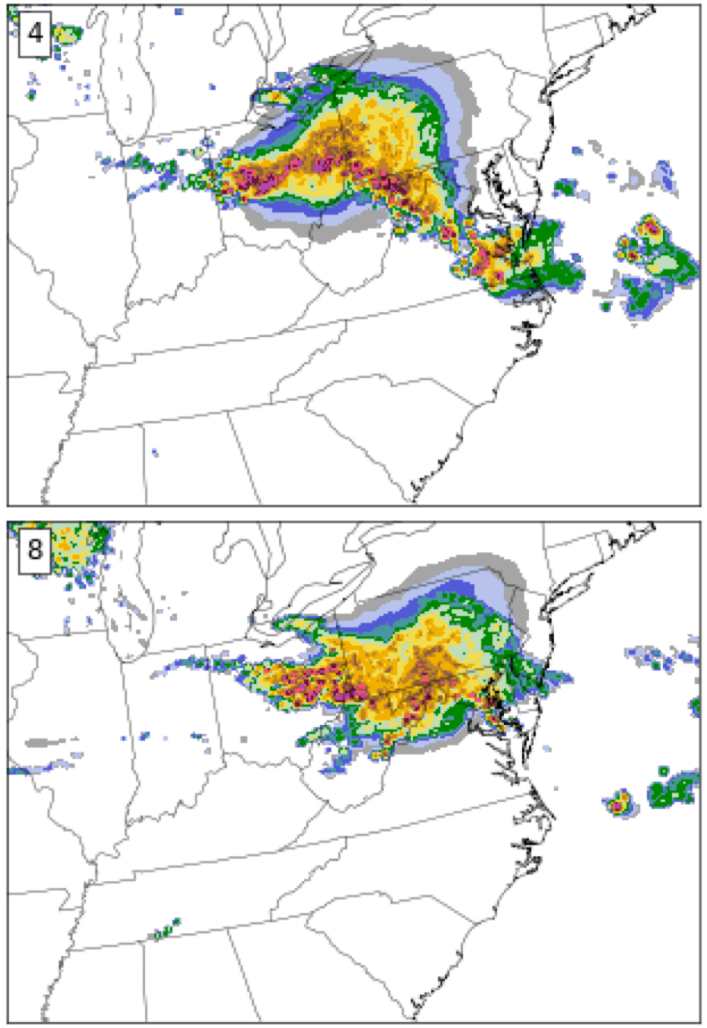
Reflectivity 09 UTC





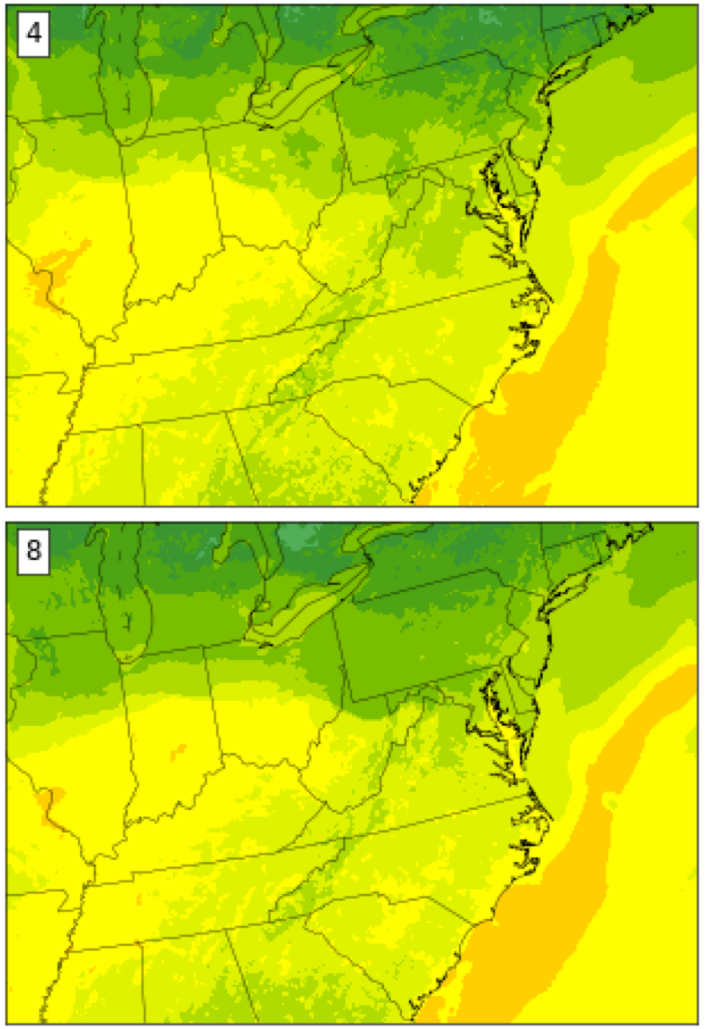
Cold pool ~7 F

Ensemble Reflectivity 09 UTC



System propagation too slow?

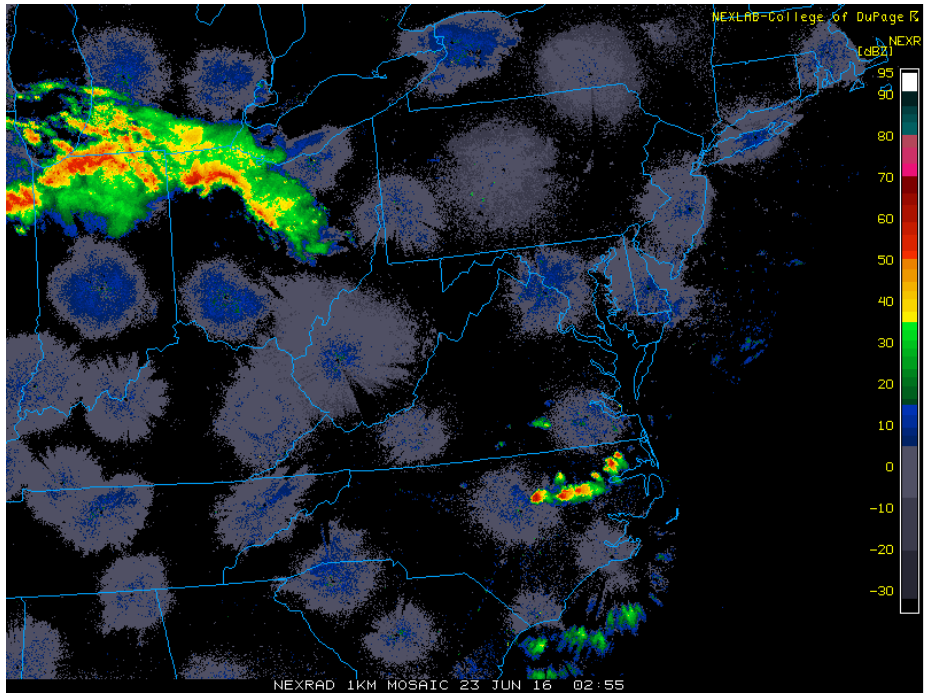
Ensemble Surface T 09 UTC



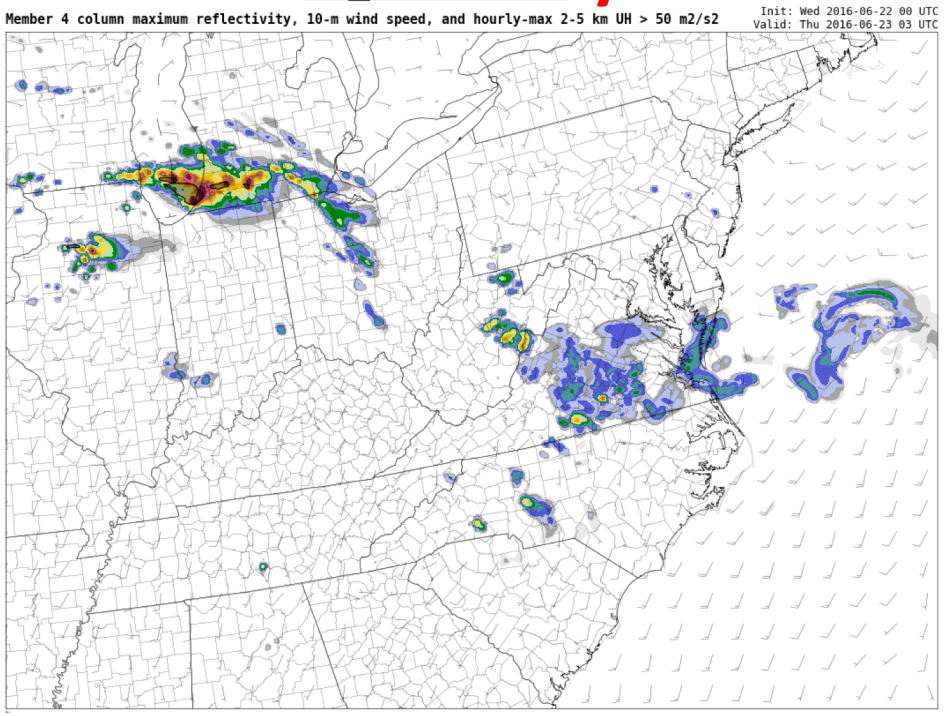
Ensemble Cold Pool ~10 F

23 June 2016

Radar



Model Reflectivity 27h

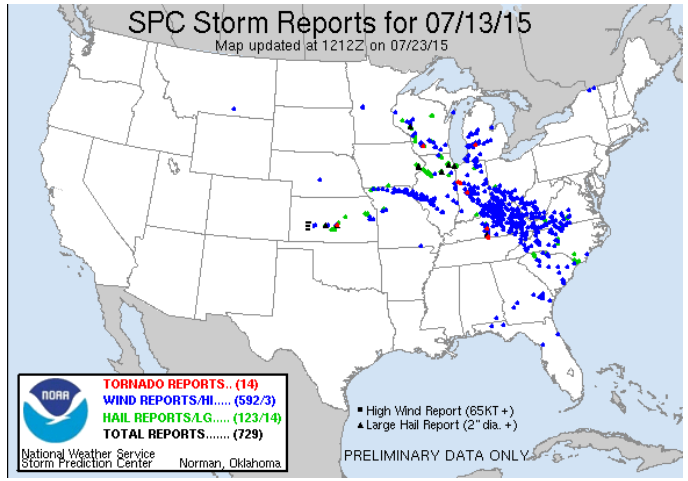


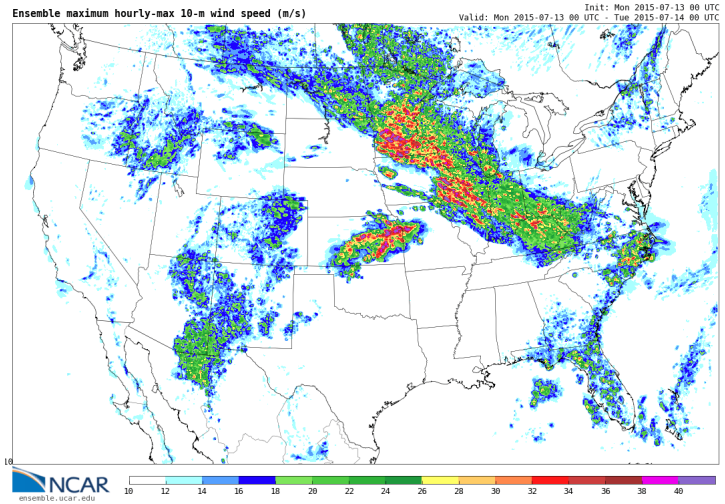
03:00 UTC

Early model convection too far northeast…

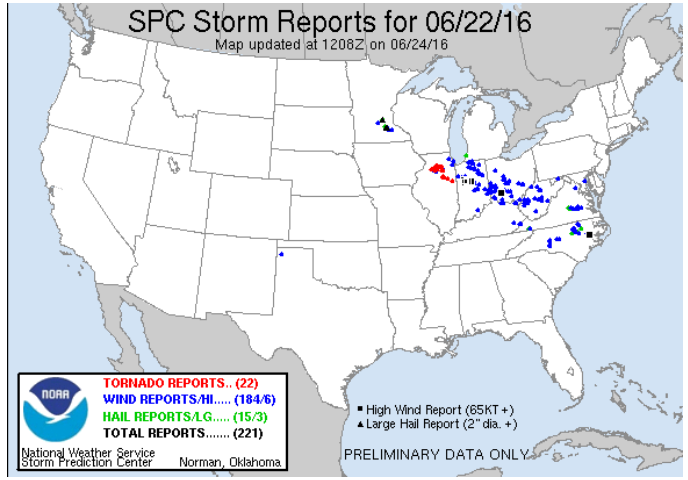
Ensemble Maximum Surface Winds:

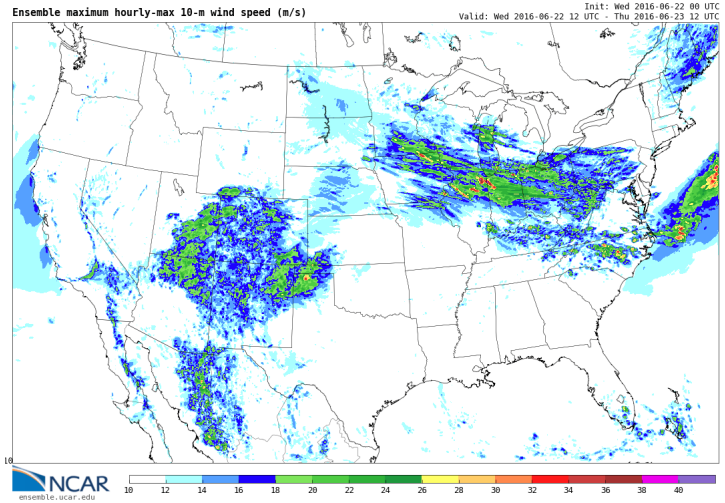
13 July 2015





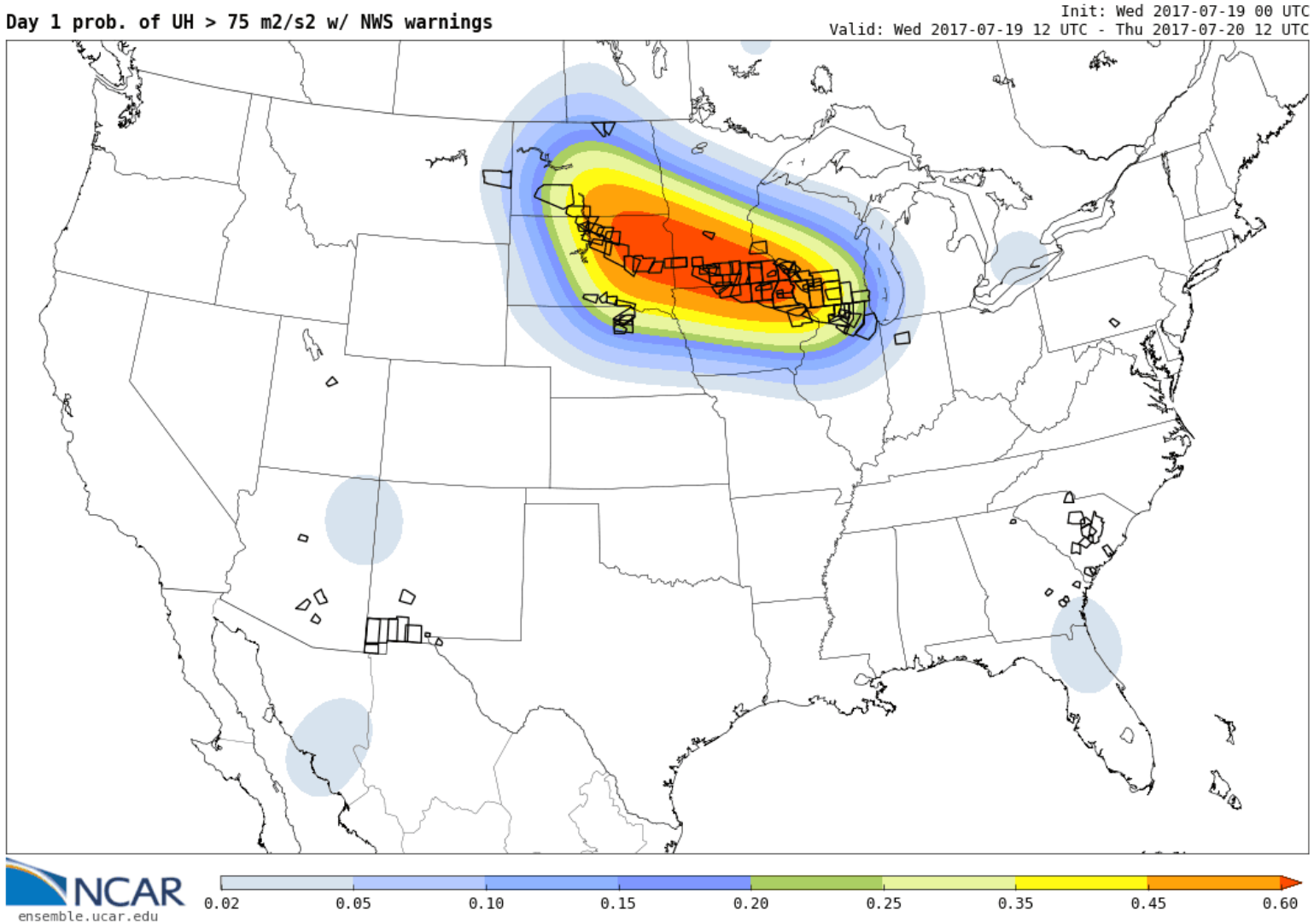
22 June 2016





Ensemble successfully distinguishes the severe weather potential (cold pool strength) for these two events

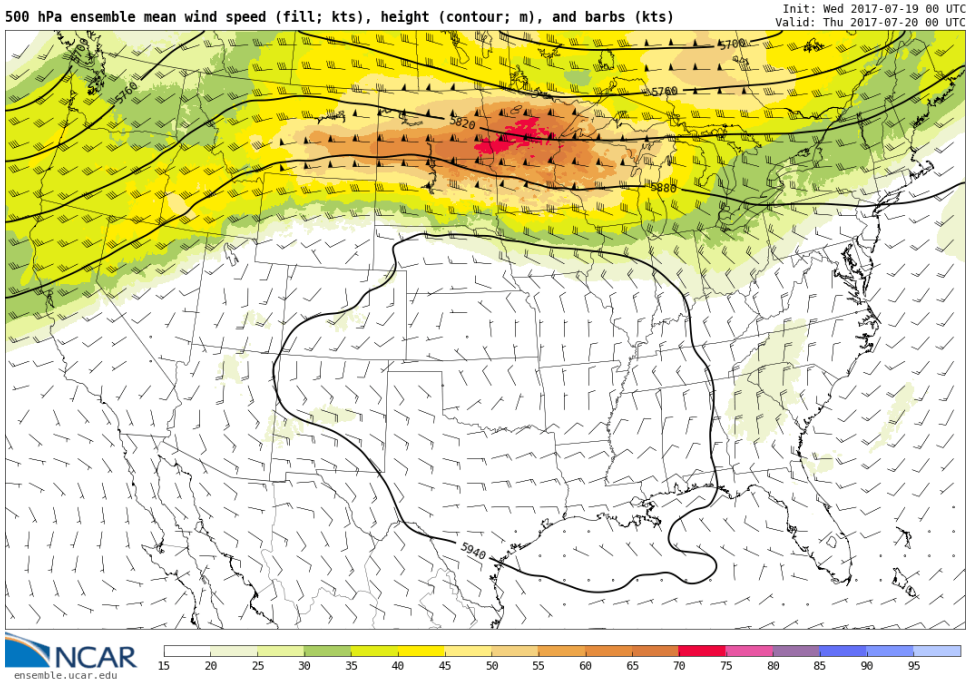
07/19/17


Day 1 prob. of UH > 75 m2/s2 w/ NWS warnings
Init: Wed 2017-07-19 00 UTC
Valid: Wed 2017-07-19 12 UTC - Thu 2017-07-20 12 UTC
NCAR
ensemble.ucar.edu
0.02
0.05
0.10
0.15
0.20
0.25
0.35
0.45
0.60

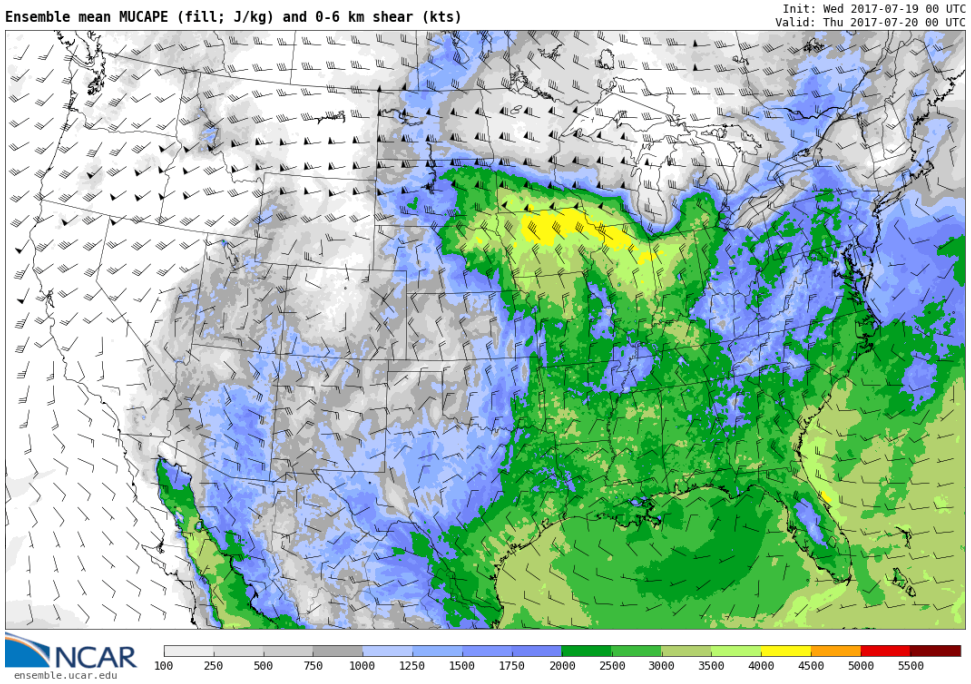
07/19/17

00 UTC 07/20

500 hPa

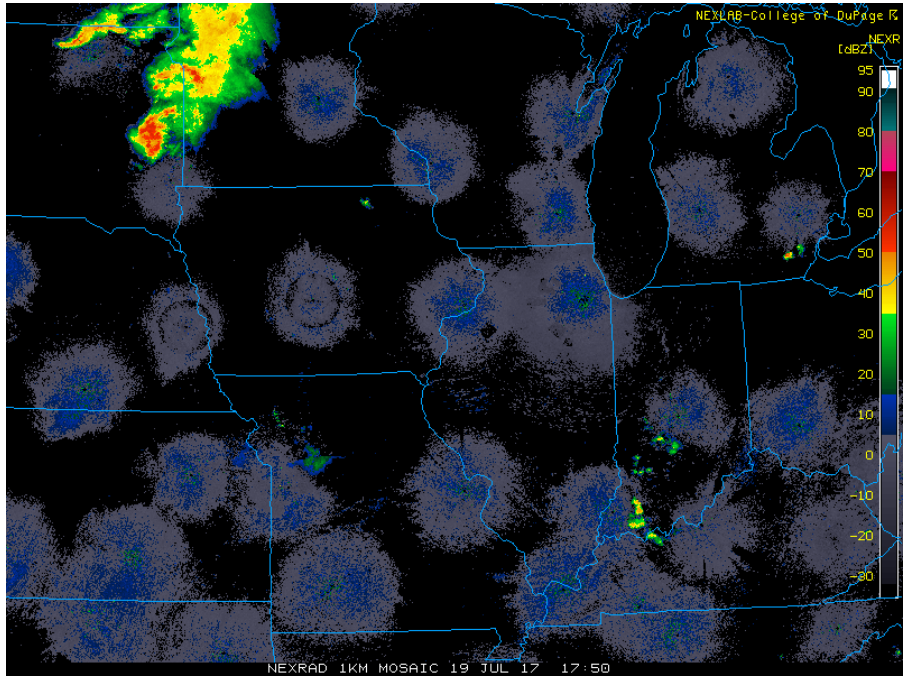


Ensemble-mean MUCAPE/ 6 km shear

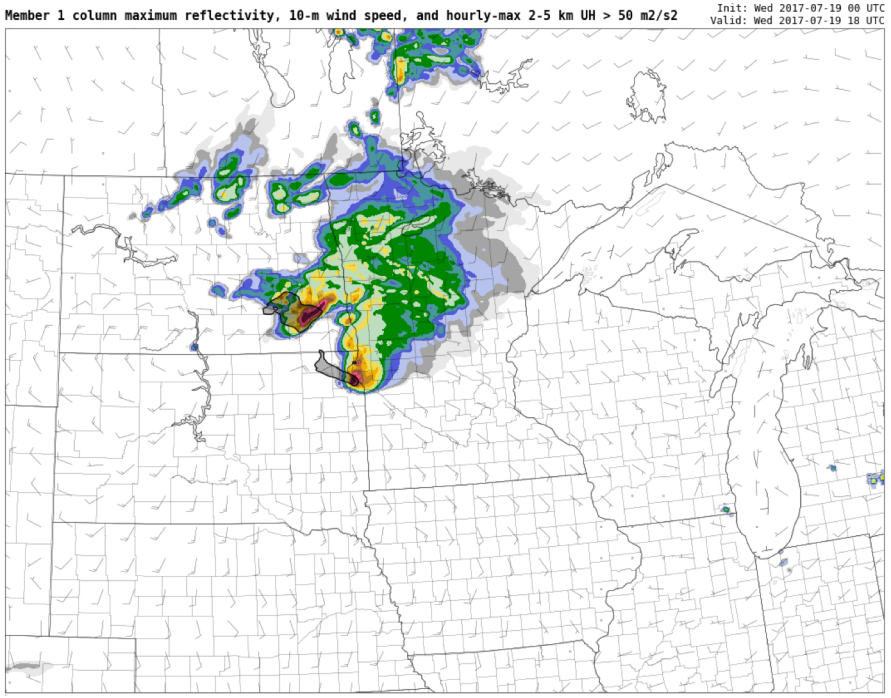


19 July 2017

Radar



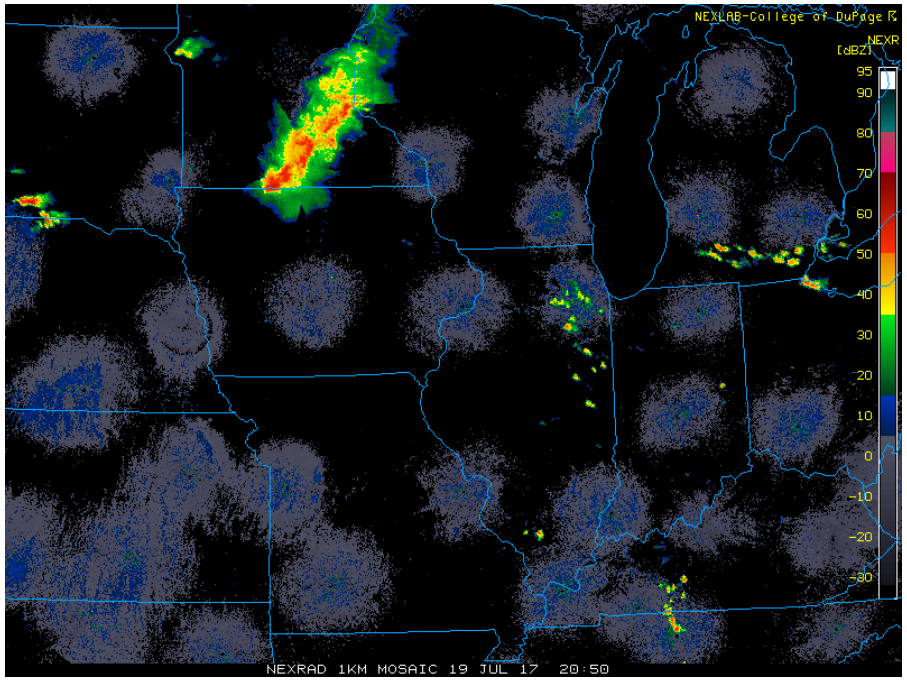
Model Reflectivitv 18h



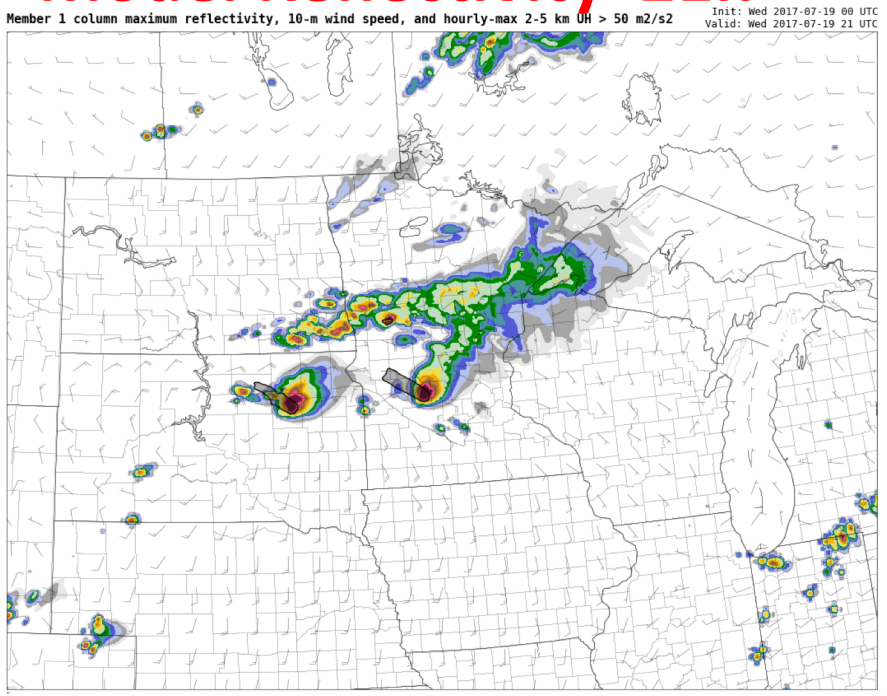
18:00 UTC

19 July 2017

Radar



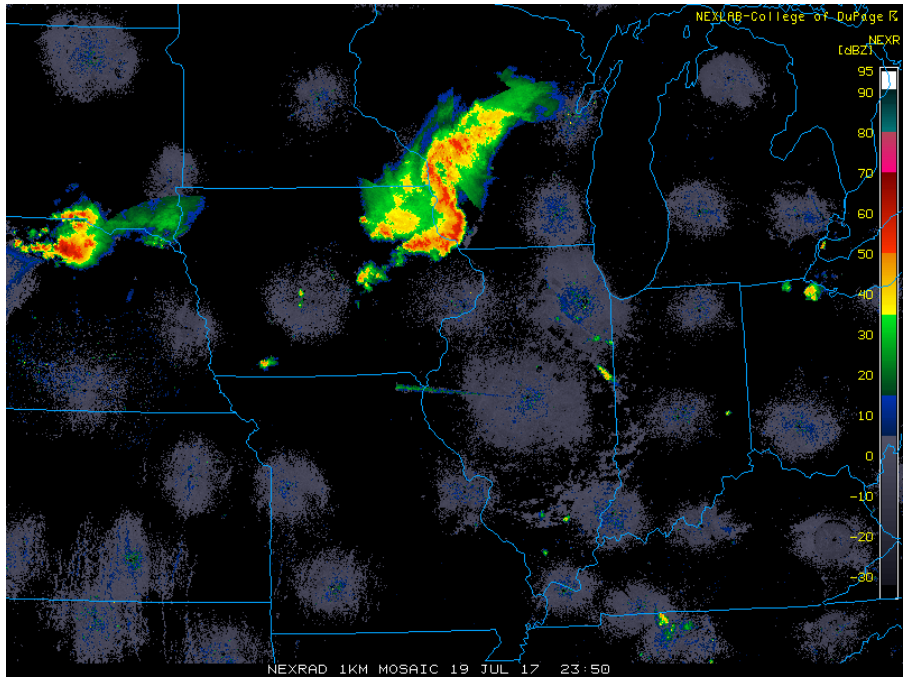
Model Reflectivity 21h



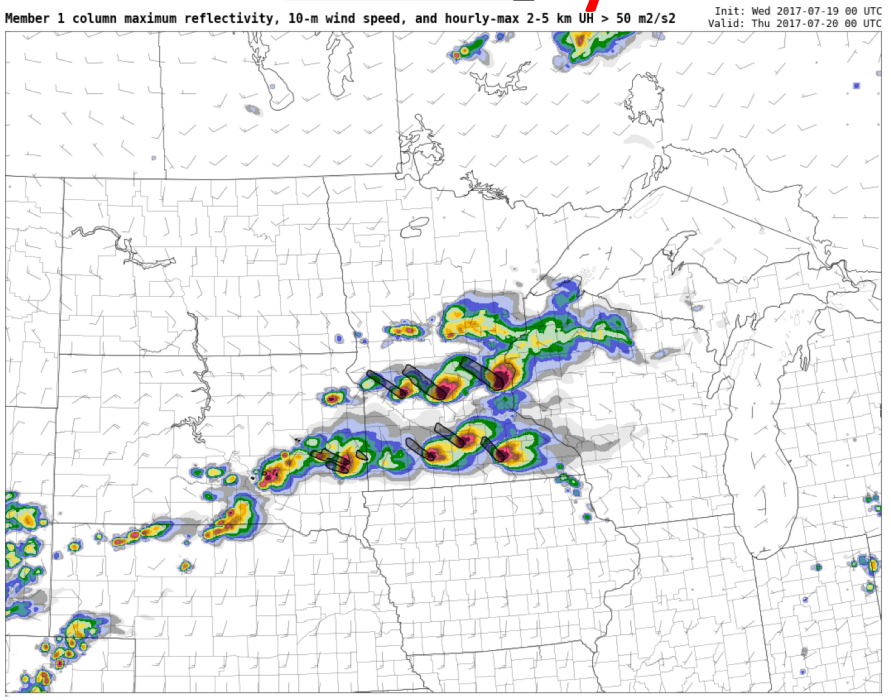
21:00 UTC

19 July 2017

Radar



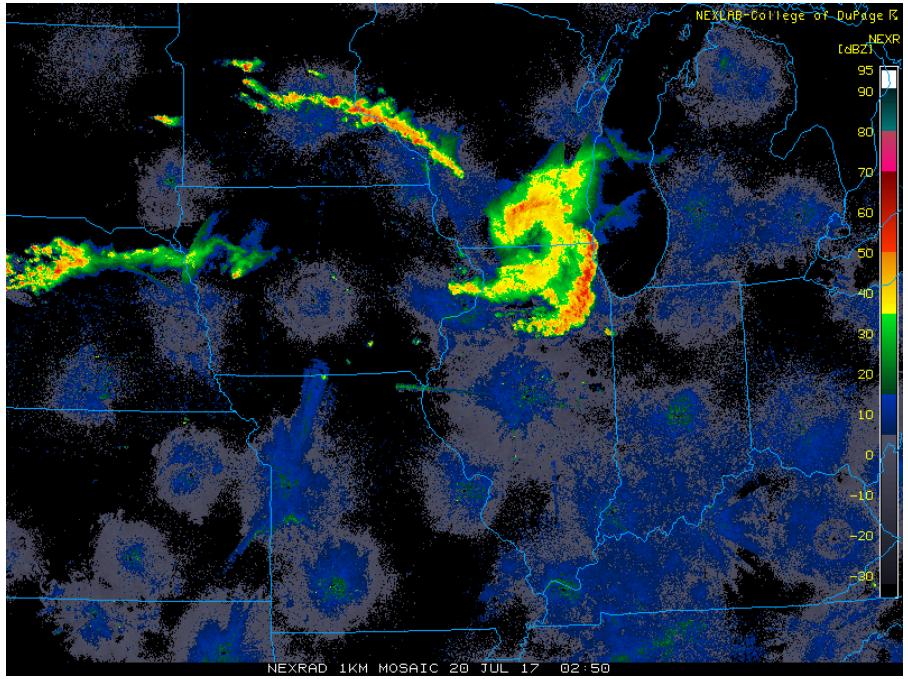
Model Reflectivity 24h



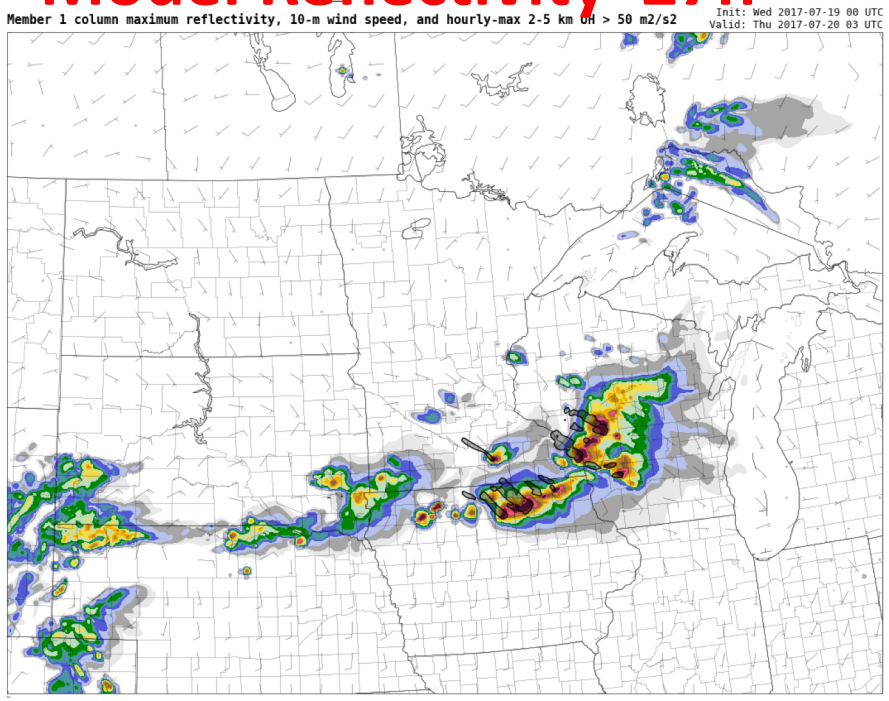
00:00 UTC

19 July 2017

Radar



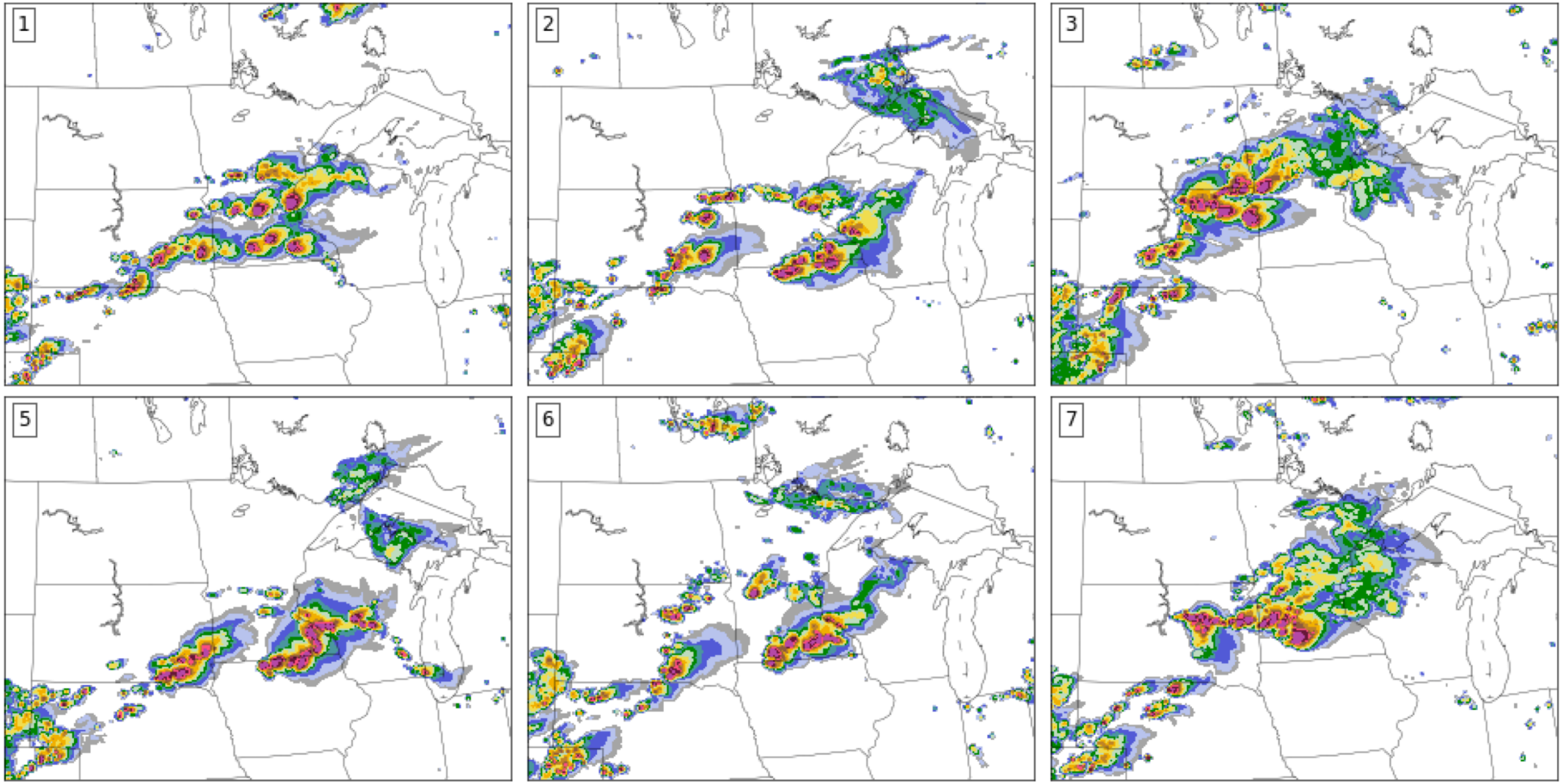
Model Reflectivity 27h



03:00 UTC

19 July 2017

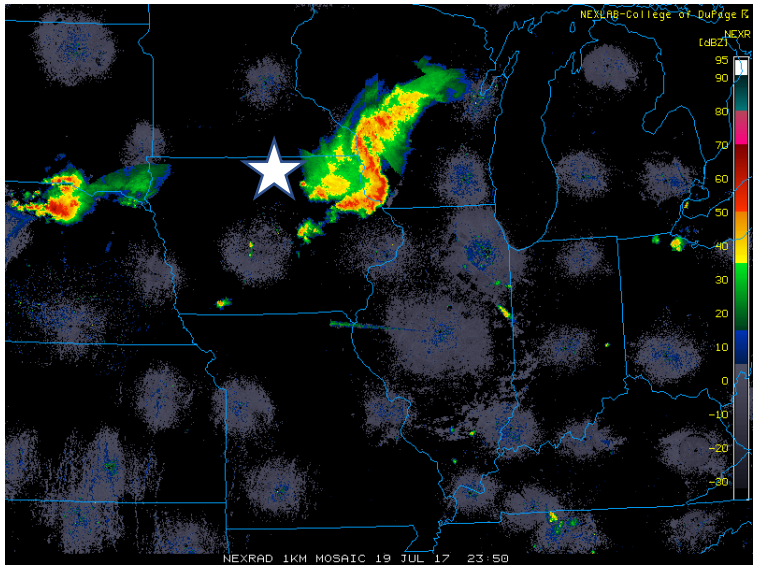
24 h forecast 6 Ensemble Members

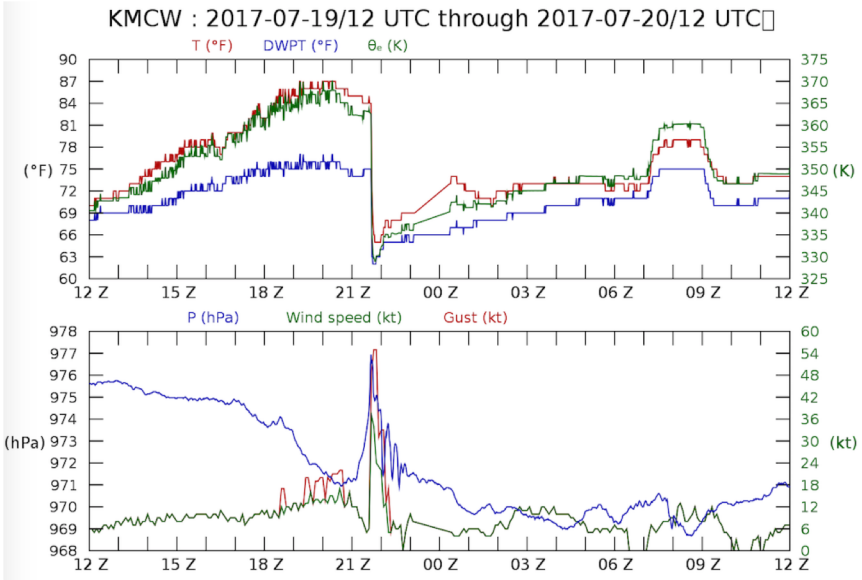


Wrong Convective Mode: Is it cold pool related?

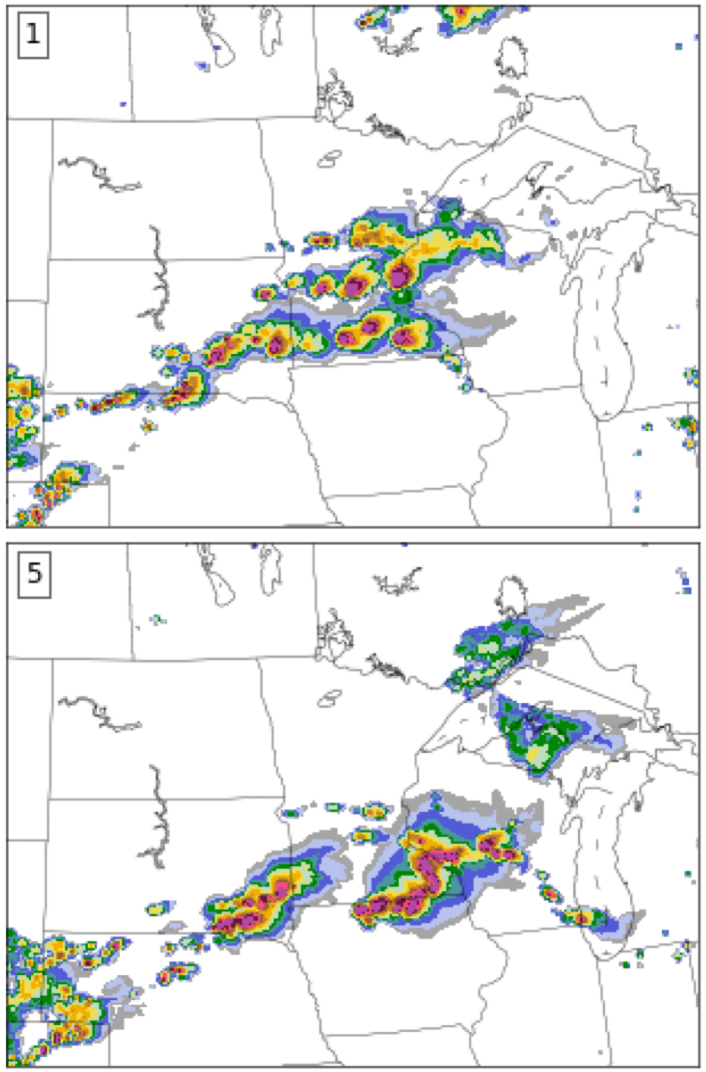
19 July 2017

Reflectivity 00 UTC

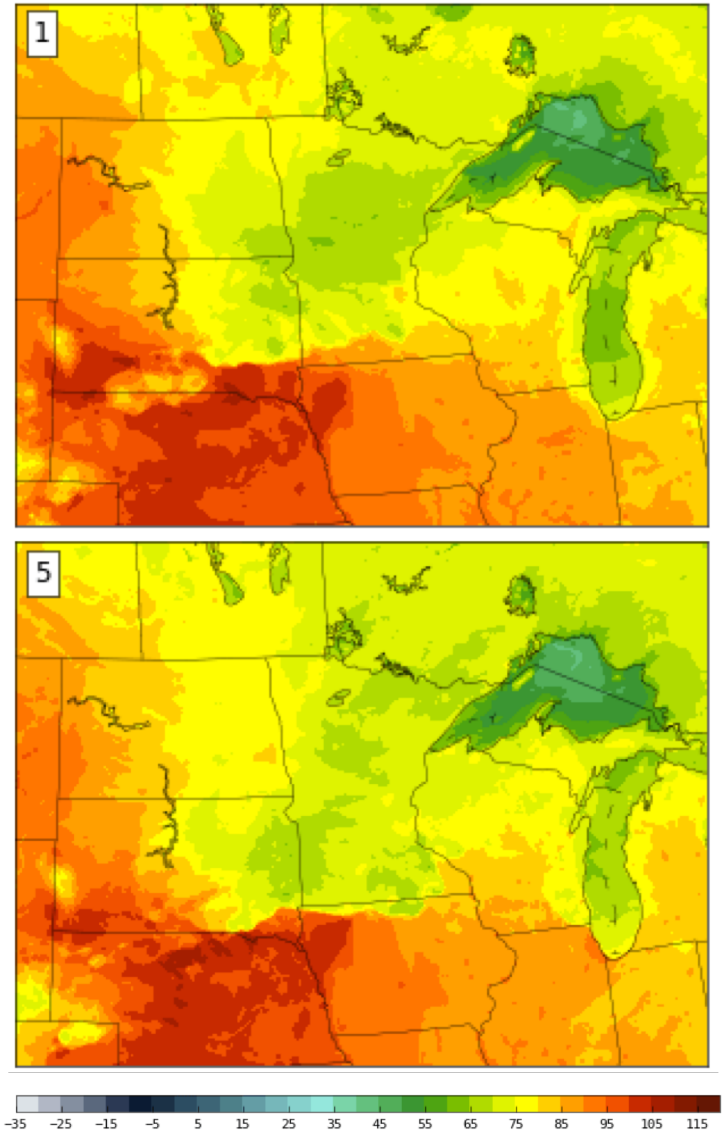




Ensemble Reflectivity 00 UTC



Ensemble Surface T 00 UTC



Cold pool ~20 F

System mode uncertain?

Ensemble Cold Pool ~20 F

Summary:

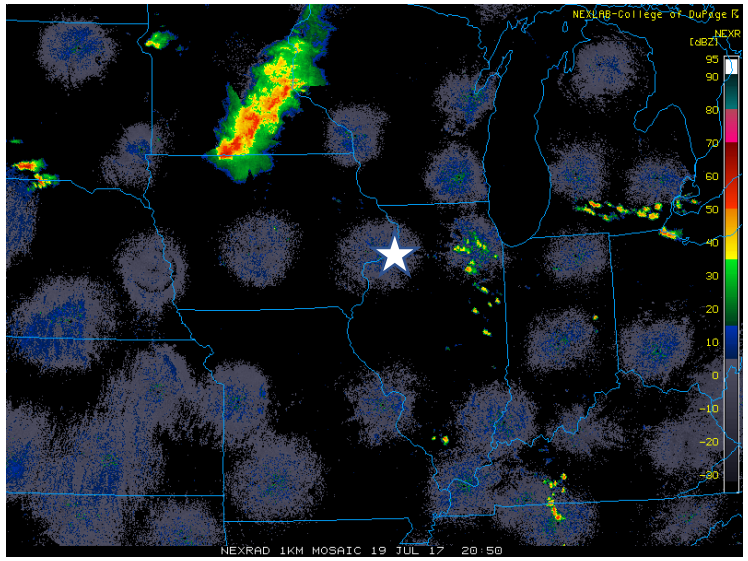
*Convective allowing (3 km) ensemble was reasonably skillfull at forecasting derecho type events

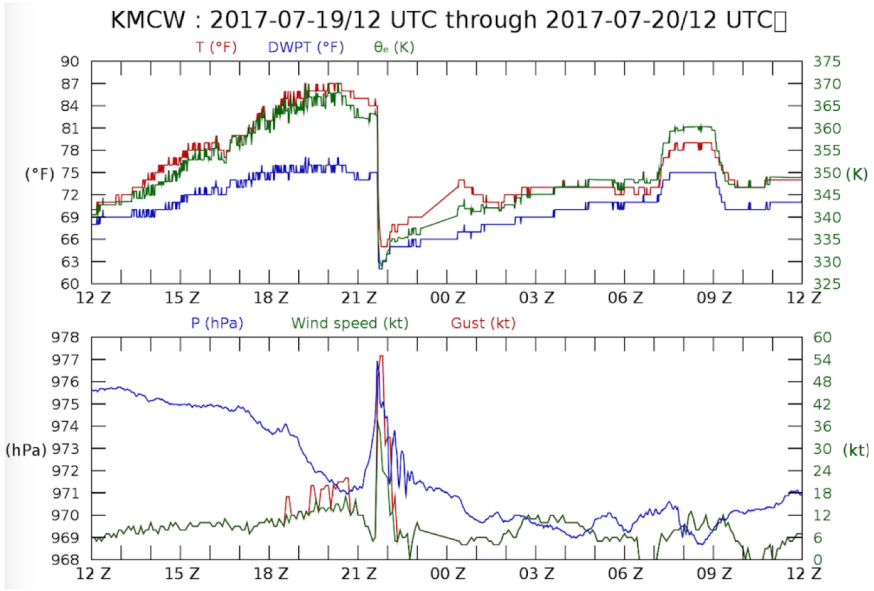
*Ensemble also reasonably good at distinguishing potential cold pool characteristics from case to case

*Derecho forecast errors more related to timing, location and character of the initial forcing rather than internal model dynamics (e.g. cold pools)

19 July 2017

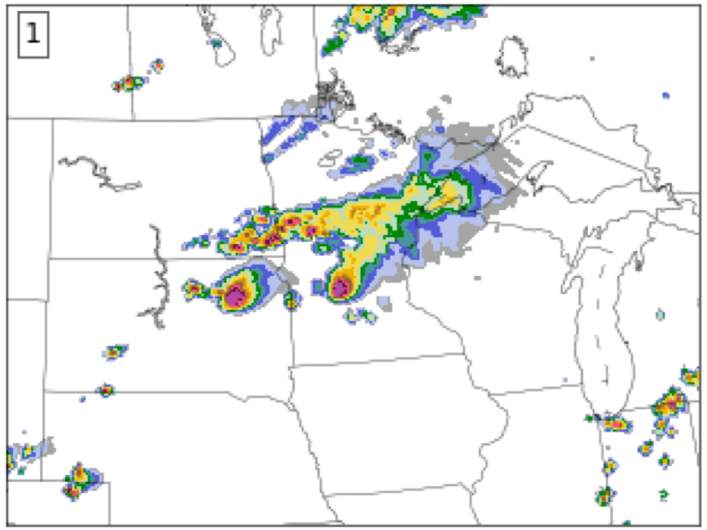
Reflectivity 21 UTC

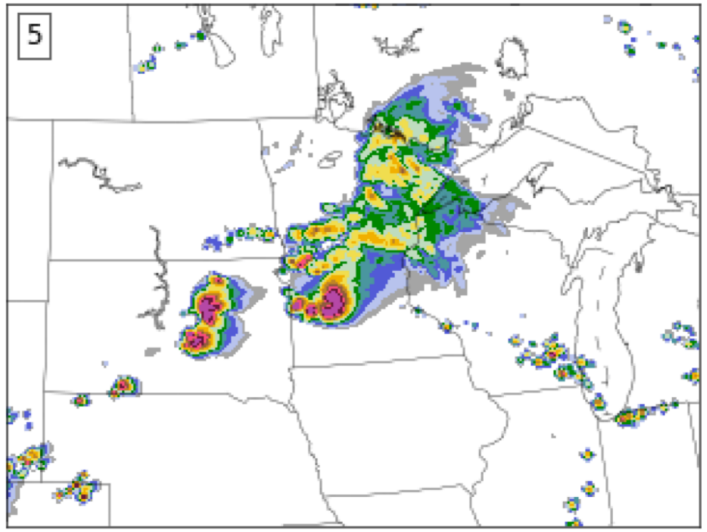




Cold pool ~20 F

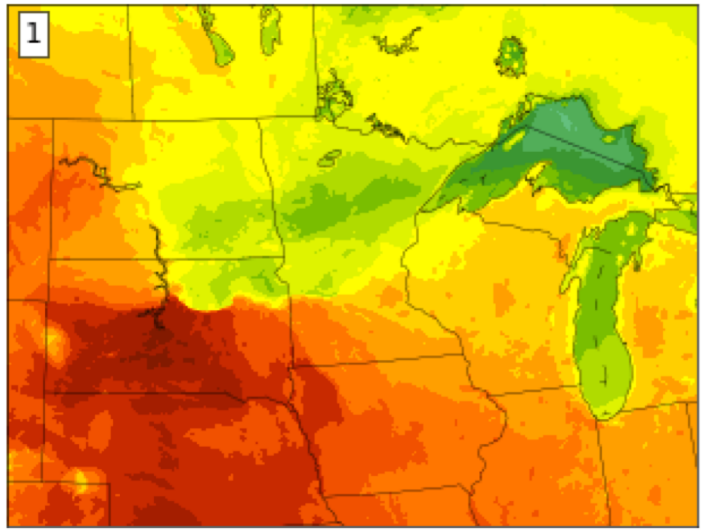
Ensemble Reflectivity

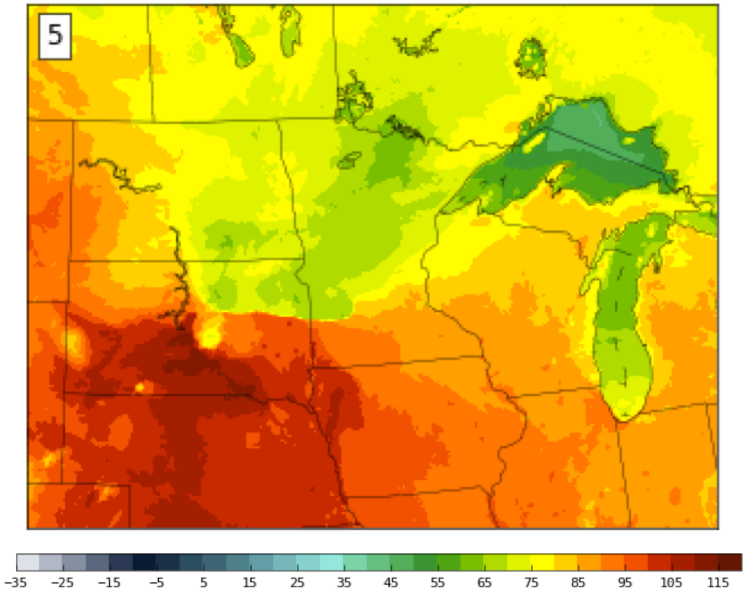




System mode uncertain?

Ensemble Surface T

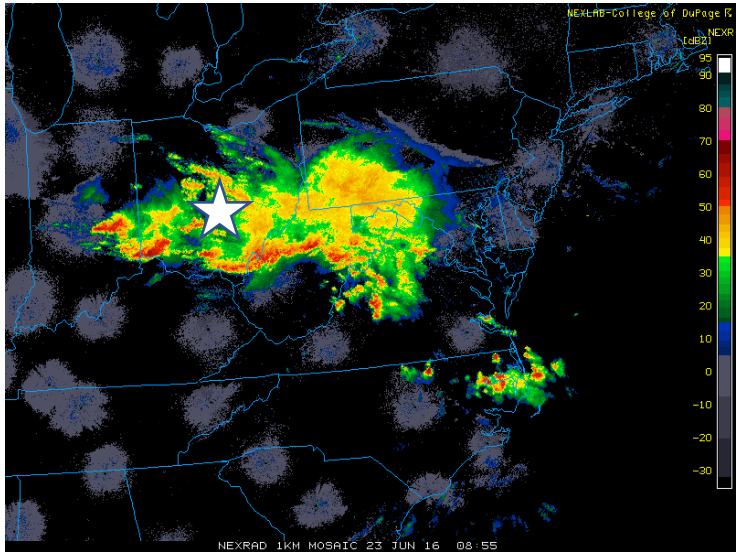


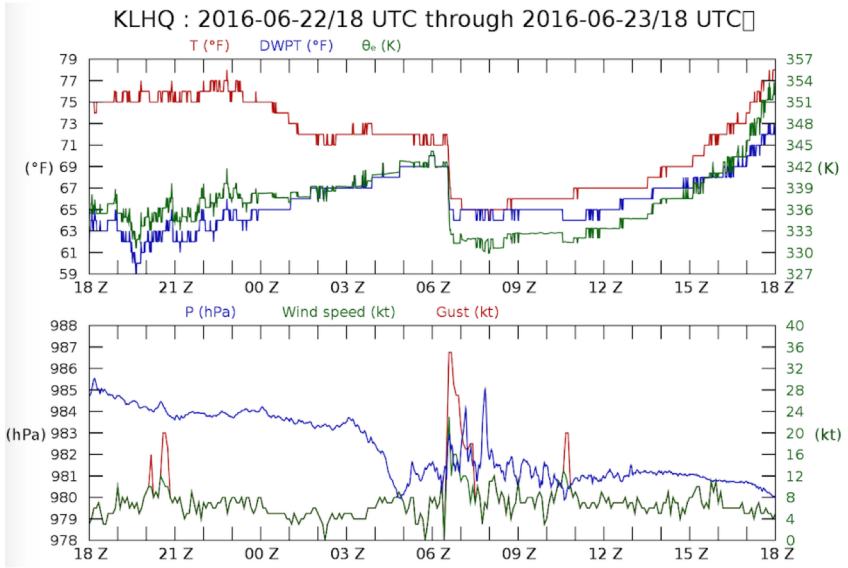


Ensemble Cold Pool ~20 F

23 June 2016

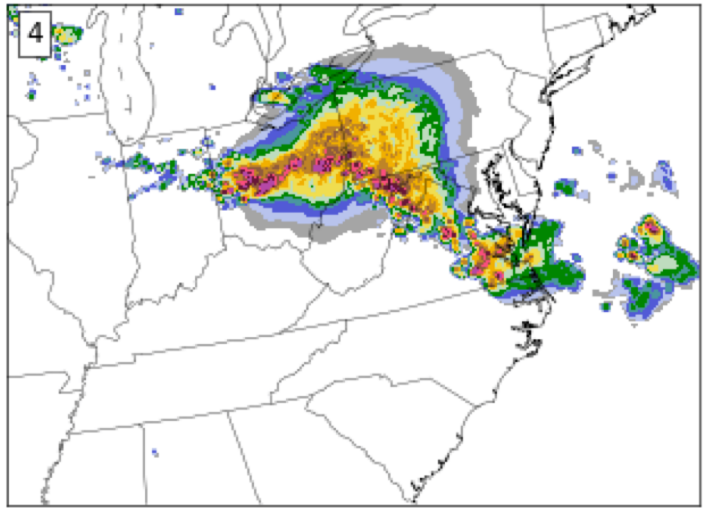
Reflectivity 09 UTC

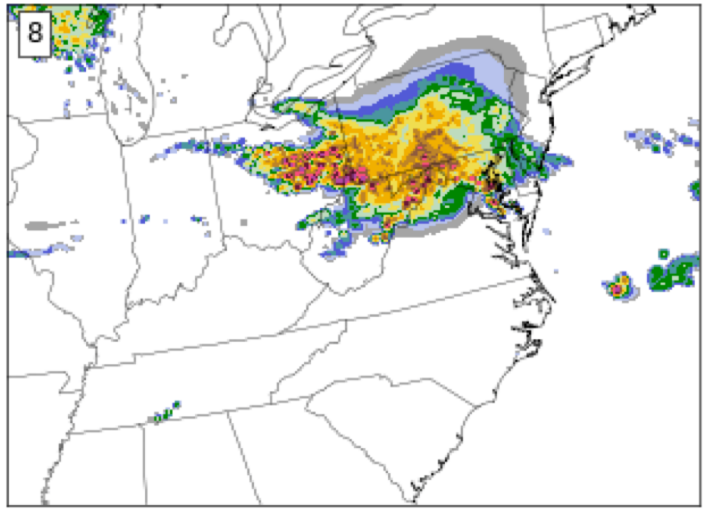




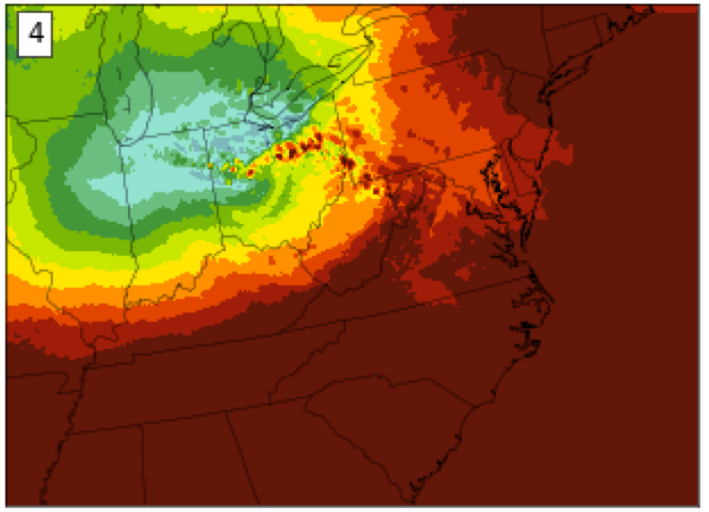
Cold pool DP ~3 hPa

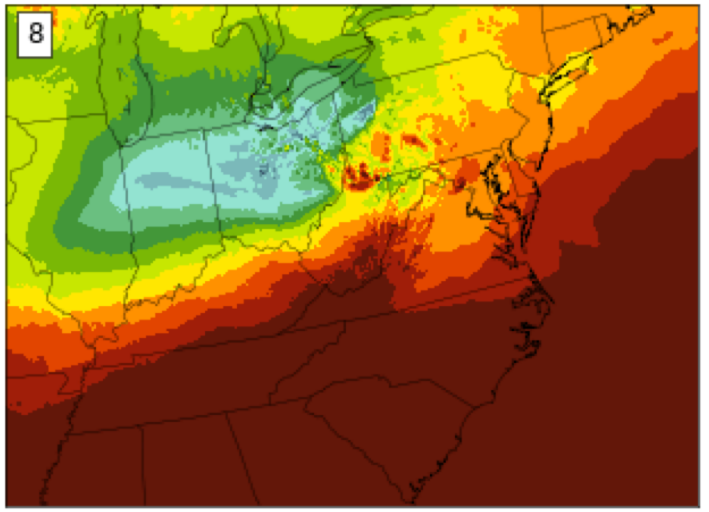
Ensemble Reflectivity 09 UTC

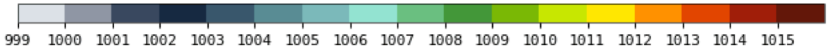




Ensemble Surface P 08 UTC







Ensemble Cold Pool DP ~4 hPa

System propagation too slow?