FV^3 at the Hazardous Weather Testbed

Lucas Harris, S-J Lin, Matt Morin,
and the GFDL FV^3 team

Special thanks to Ming Xue,
Tim Supinie, and Bill Putman

Community involvement with development from day 1

- Collaborating with OU-CAPS on convection-resolving model development
- Examination of a **very** early “version 0” of FV^3-powered CRM by severe weather experts at SPC to get feedback from established modelers and users from the very beginning.
- Beginning development of stand-alone regional model with EMC, for university users and others with limited computing capacity
- Open invitation for interested parties to visit GFDL to work on fvGFS and other model development efforts. EMC has already committed three developers to visit GFDL.

fvGFS Design and setup

fvGFS = FV^3 + GFS Physics + NOAH land model

13-km global and 13 & 3-km CONUS nest

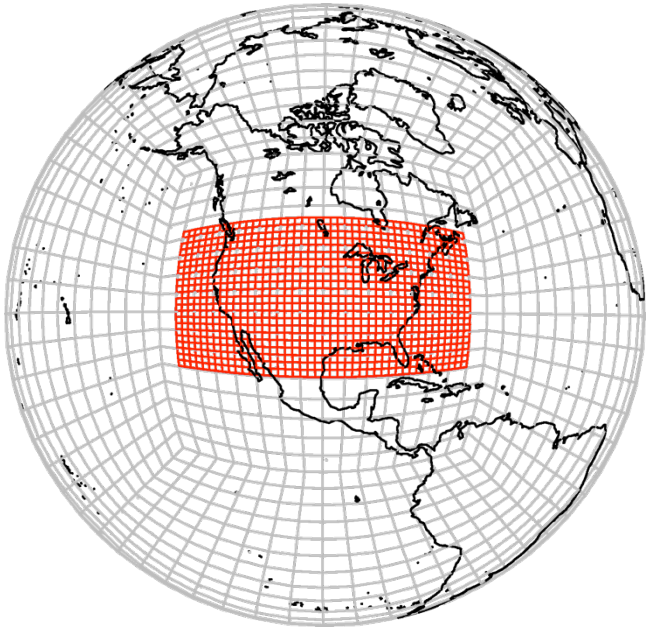
replace GFS Zhao-Carr with six-category GFDL microphysics

Uses IPDv4 designed at GFDL:

Prepared for future physics upgrades!

Model cold-started from GFS analyses.

No regional initialization.



fvGFS Design and setup

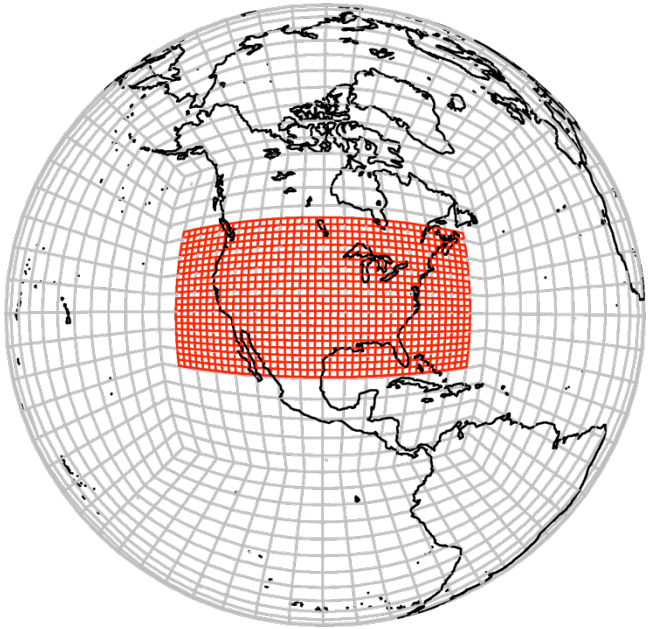
fvGFS = FV^3 + GFS Physics + NOAH land model

Nested-grid uses neither shallow nor deep convection; global grid uses scale-aware SAS

GFS PBL scheme mixing artificially halved and inversion mixing disabled. (Still too much mixing?)

~19 minutes/day 3456 PEs on Gaea-c4,
slightly more on xJet

Post-processed GRIB data usually at HWT before 09Z



fvGFS Development Strategy

13-km fvGFS has excellent global skill and shows regional improvements.

Global-to-regional refinement promises to remove limitations of limited-area models: **no lateral BCs from another model!**

Nesting allows us to use physics with global skill in global domain, and physics with regional skill in **targeted** regional domain.

Goal: Maintain large-scale skill while adding storm-scale information on 3-km nest

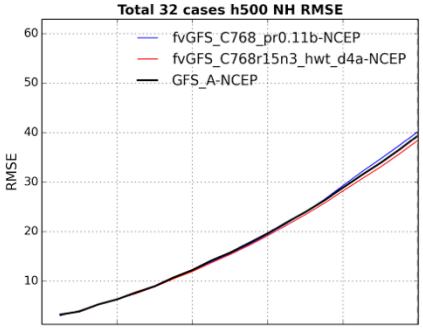
Can we get good qualitative skill for all seasons as well as useful qualitative storm-scale information??

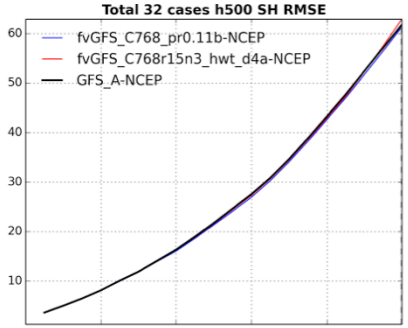
Objective Skill Scores

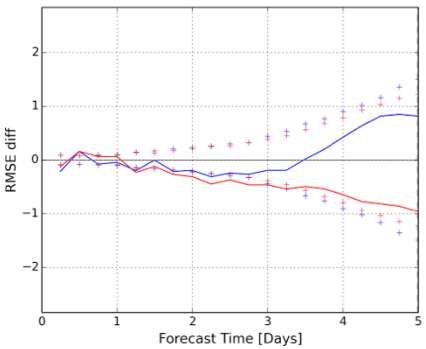
(Warning: small sample size)

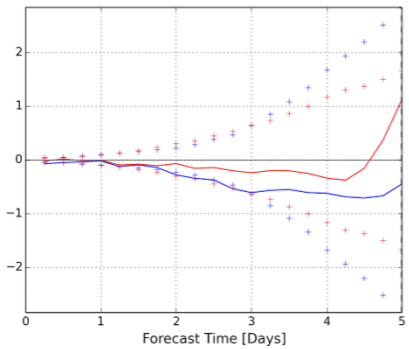
April 2017 (32 00Z cases)

Hemispheric RMSE (lower is better)

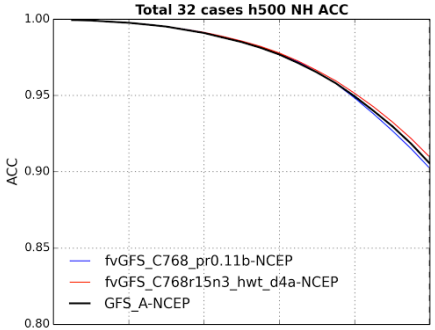


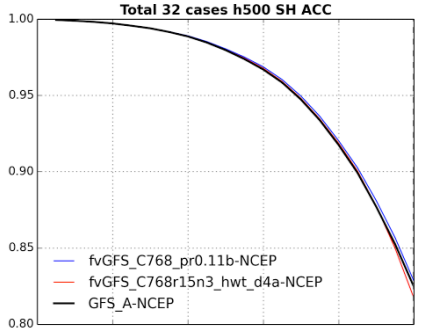


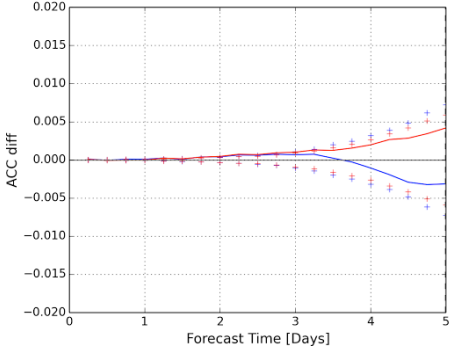


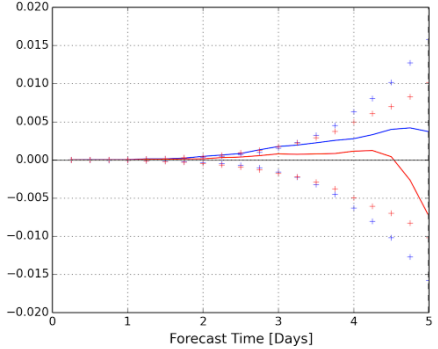


Hemispheric ACC (higher is better)







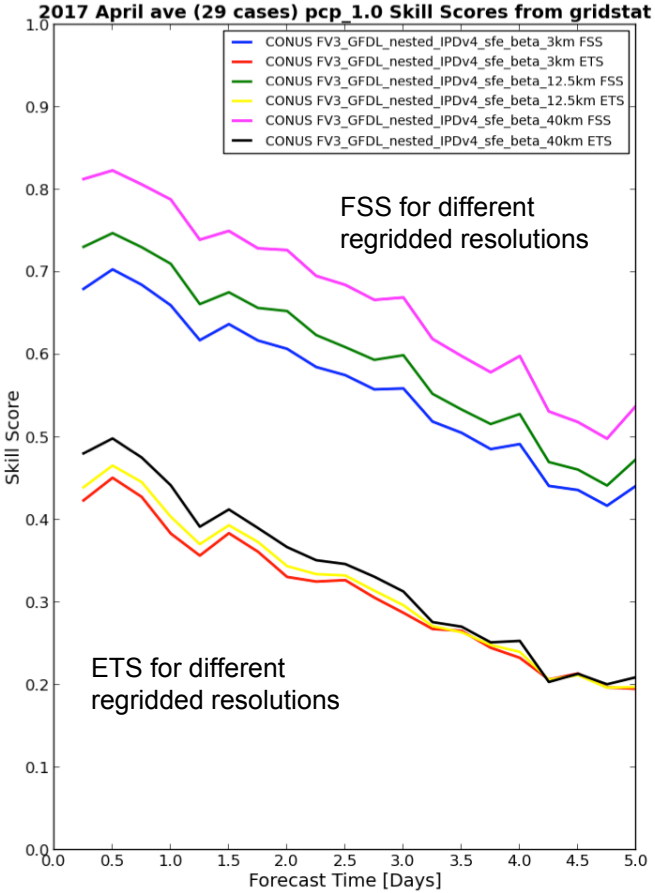


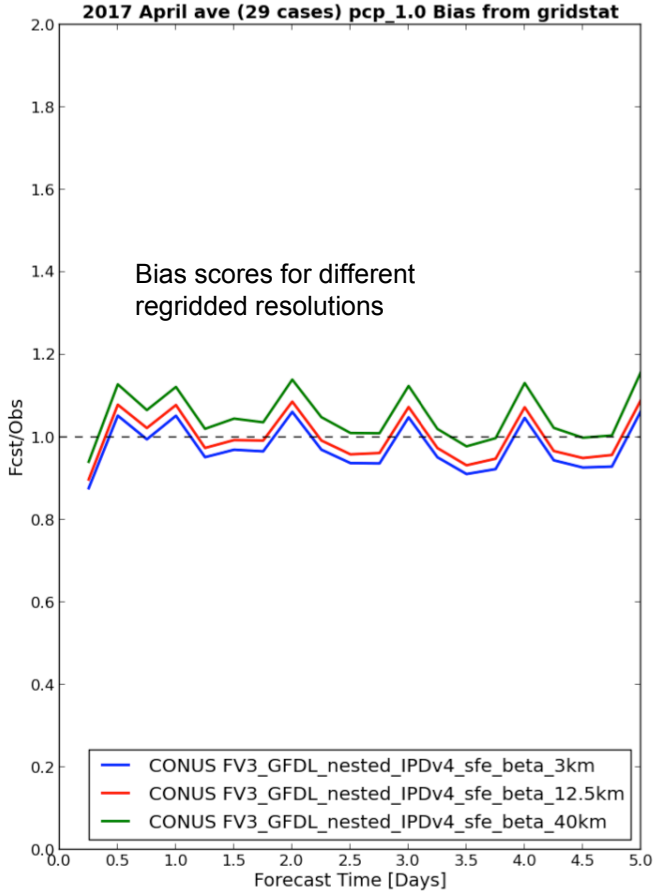
Blue: 13-km global (NUOPC 3 version)

Red: 13 & 3-km global-to-CONUS (IPDv4 version)

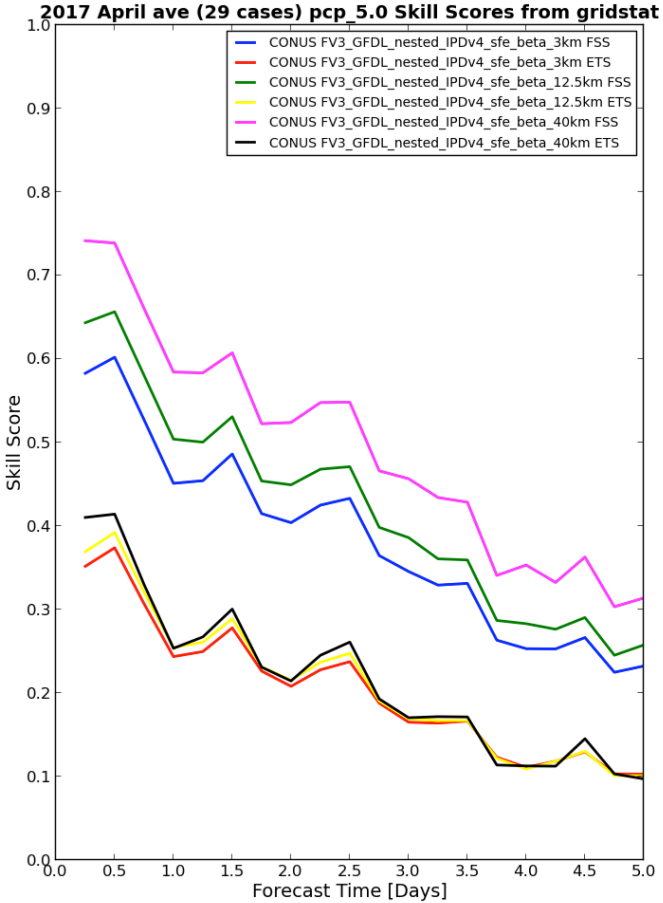
Precipitation Events >= 1.0mm/6hr

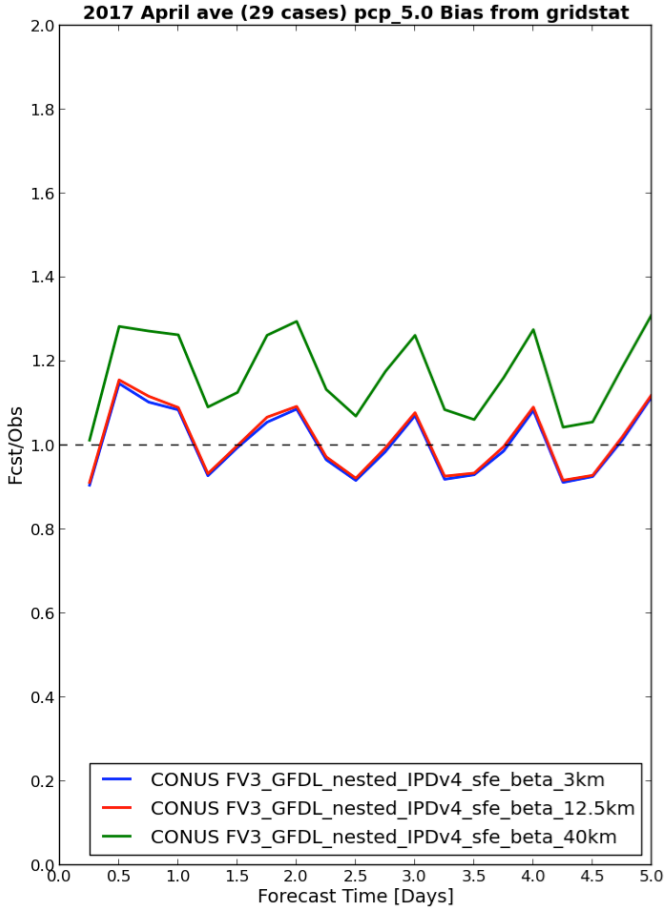
3-km fvGFS, 3x3 cell neighborhoods



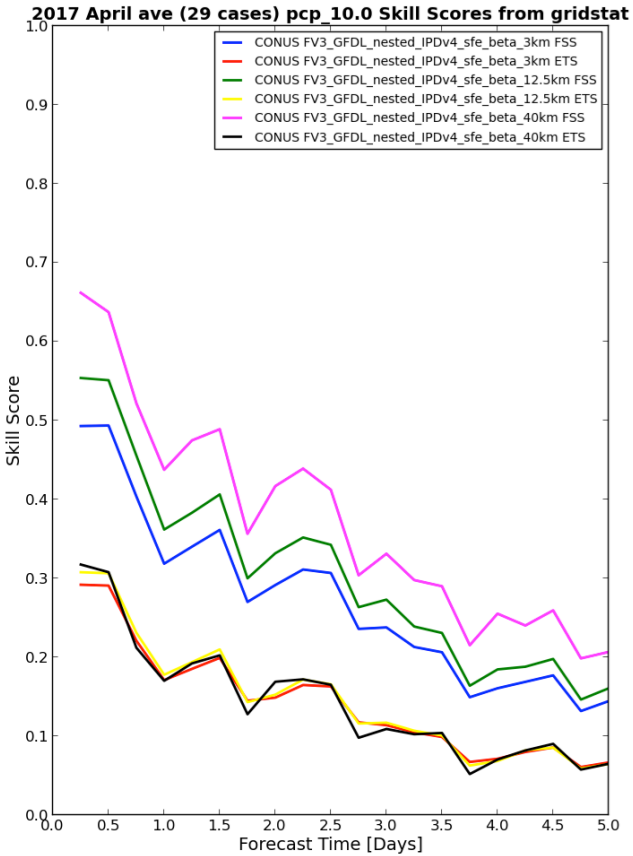


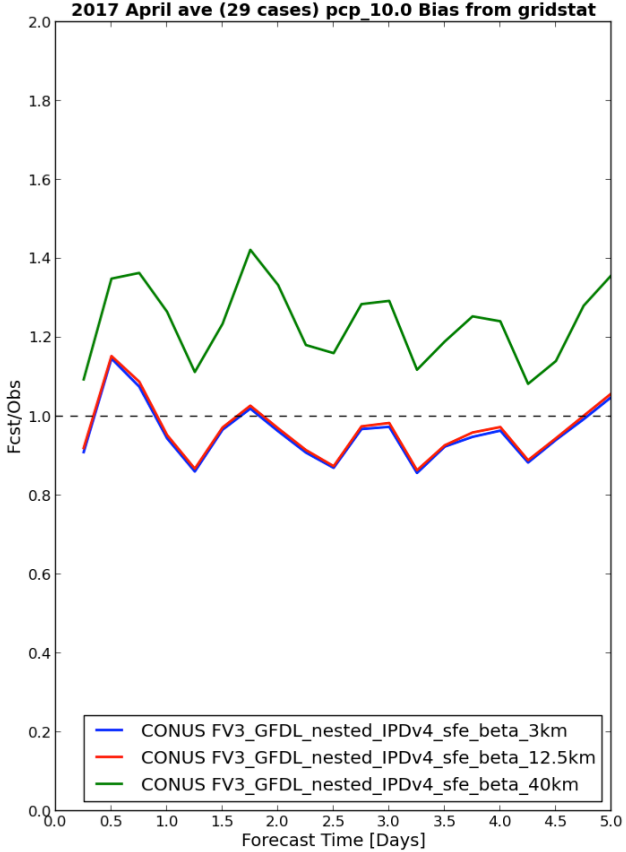
Precipitation Events >= 5.0mm/6hr





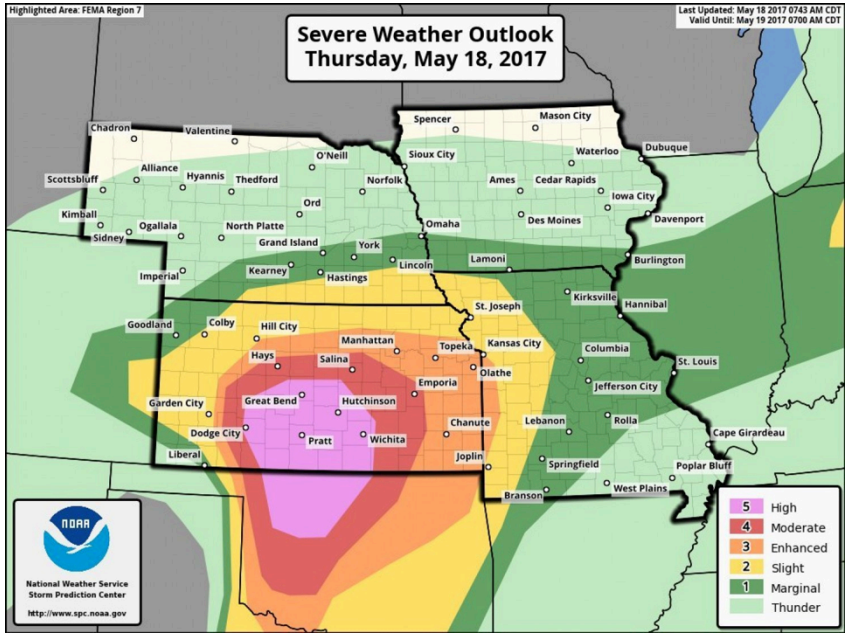
Precipitation Events >= 10.0mm/6hr

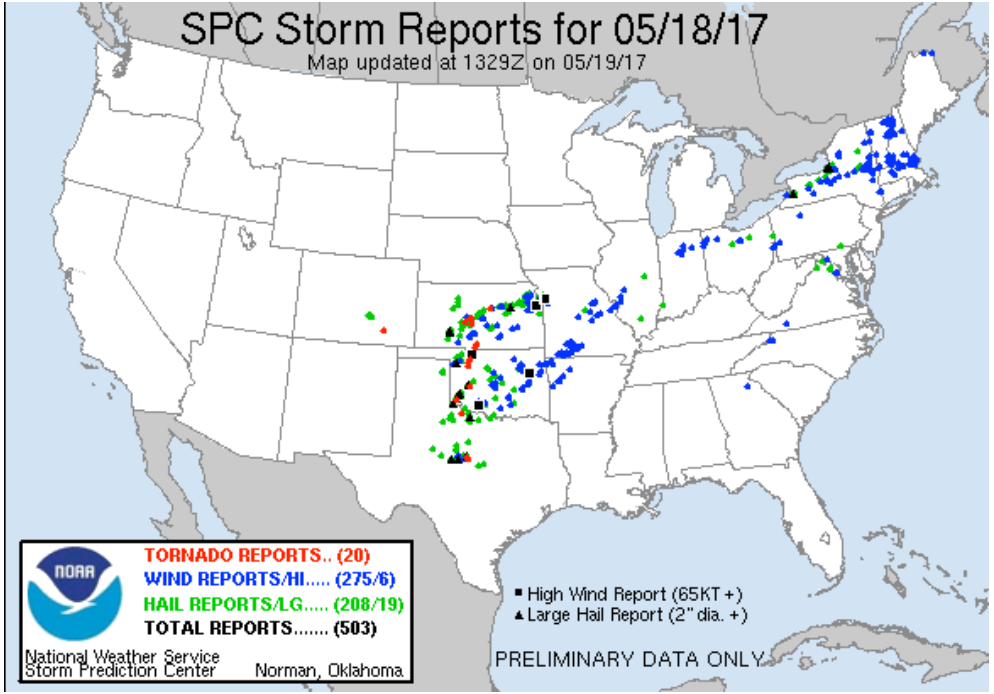


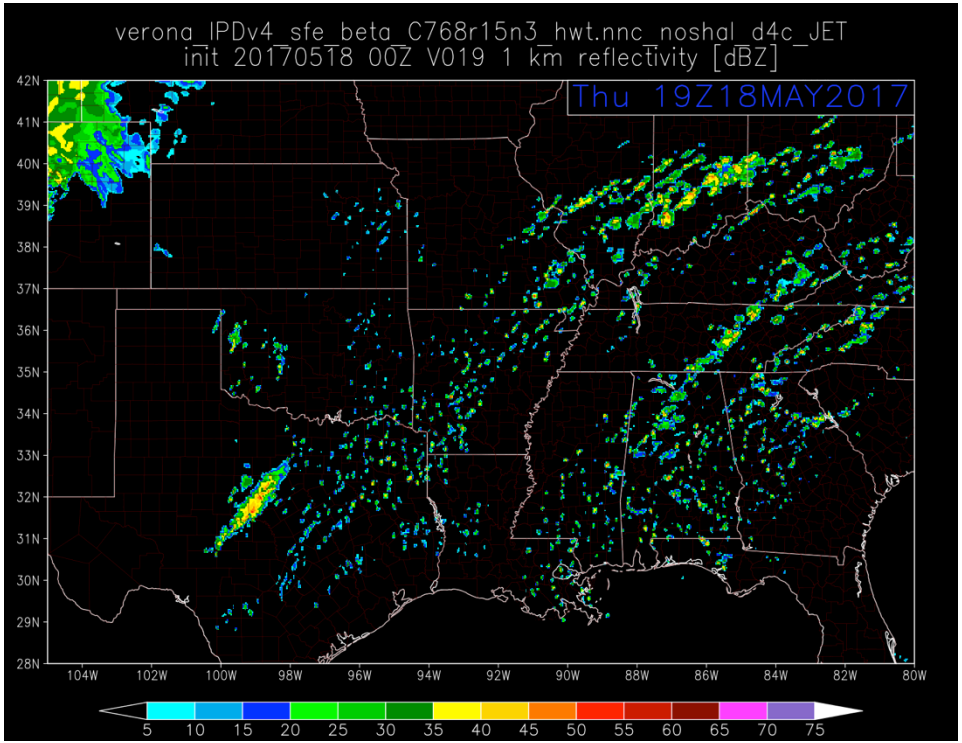


18 May OK-KS **High Risk**

GOES-16 1-min band 2 visible


Highlighted Area: FEMA Region 7
Last Updated: May 18 2017 0743 AM CDT
Valid Until: May 19 2017 0700 AM CDT
Severe Weather Outlook
Thursday, May 18, 2017
Chadron
Valentine
Spencer
Mason City
O'Neill
Sioux City
Waterloo
Dubuque
Alliance
Scottsbluff
Hyannis
Thedford
Norfolk
Ames
Cedar Rapids
Iowa City
Ord
Kimball
Ogalala
North Platte
Omaha
Des Moines
Davenport
Sidney
Grand Island
York
Lincoln
Lamoni
Burlington
Imperial
Kearney
Hastings
Kirksville
Hannibal
St. Joseph
Goodland
Colby
Hill City
Manhattan
Topeka
Kansas City
Columbia
Hays
Salina
Olathe
St. Louis
Emporia
Jefferson City
Garden City
Great Bend
Hutchinson
Chanute
Lebanon
Rolla
Dodge City
Pratt
Wichita
Cape Girardeau
Liberal
Joplin
Springfield
Poplar Bluff
Branson
West Plains
5 High
4 Moderate
3 Enhanced
2 Slight
1 Marginal
Thunder
National Weather Service
Storm Prediction Center
http://www.spc.noaa.gov


SPC Storm Reports for 05/18/17
Map updated at 1329Z on 05/19/17
TORNADO REPORTS.. (20)
WIND REPORTS/HI..... (275/6)
HAIL REPORTS/LG..... (208/19)
TOTAL REPORTS..... (503)
National Weather Service
Storm Prediction Center
Norman, Oklahoma
High Wind Report (65KT+)
Large Hail Report (2" dia. +)
PRELIMINARY DATA ONLY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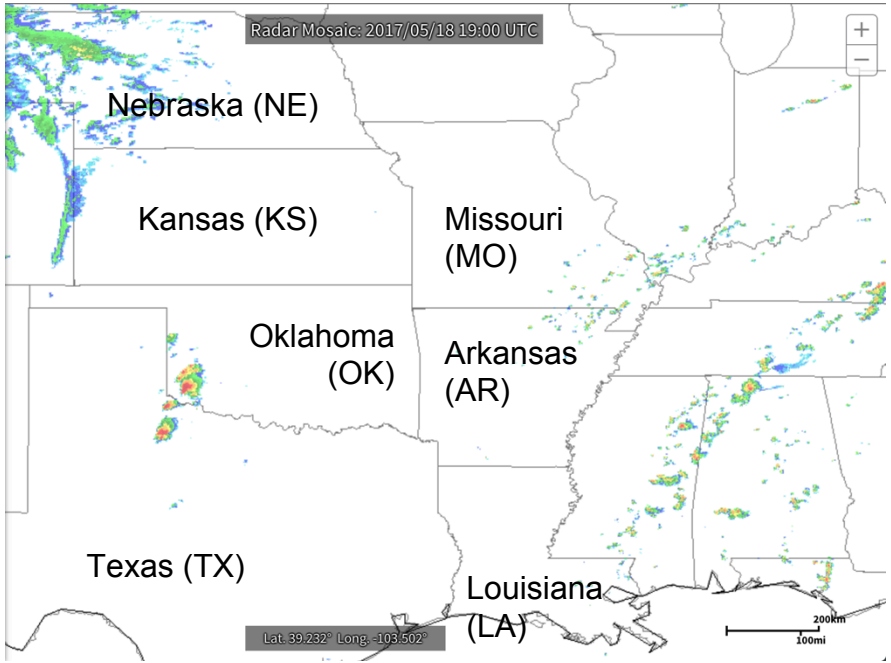
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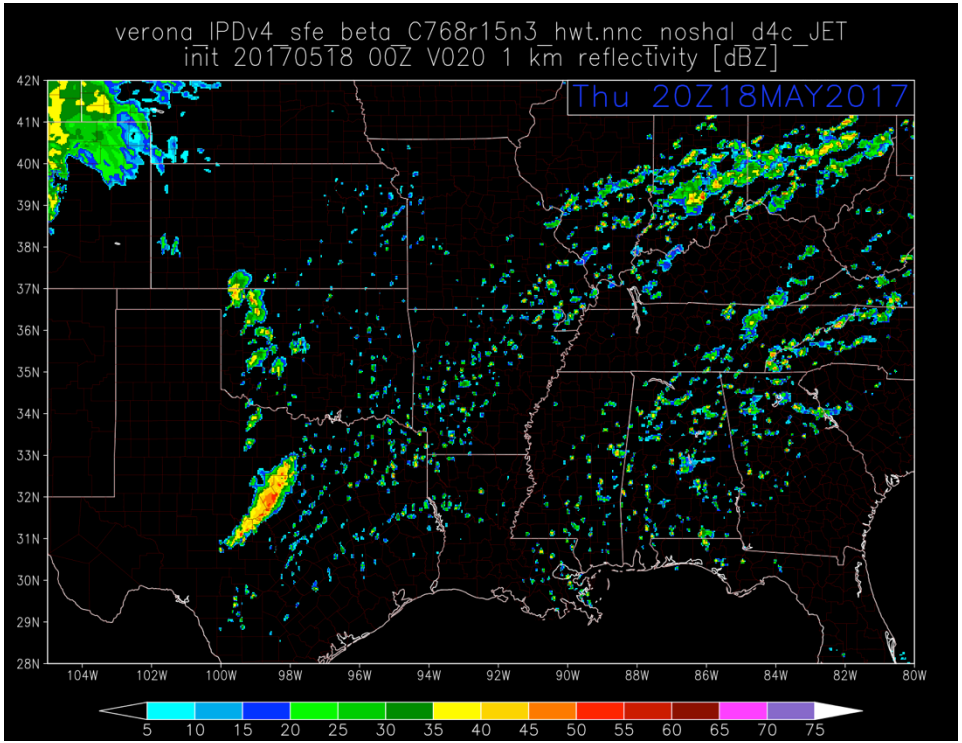
Nebraska (NE)
Kansas (KS)
Missouri (MO)
Oklahoma (OK)
Arkansas (AR)
Texas (TX)
Louisiana (LA)
Lat: 39.232° Long: -103.502°
200km
100mi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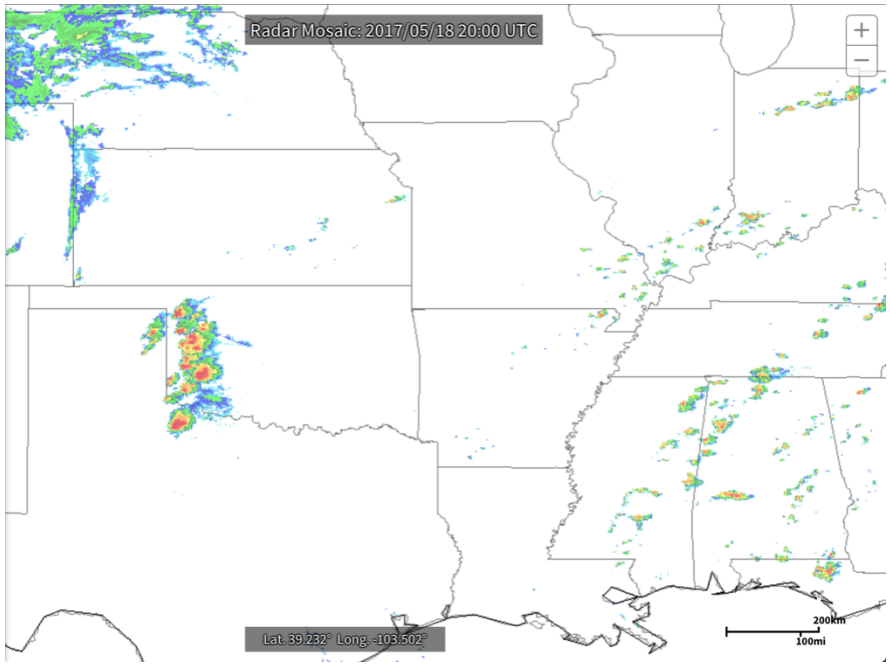
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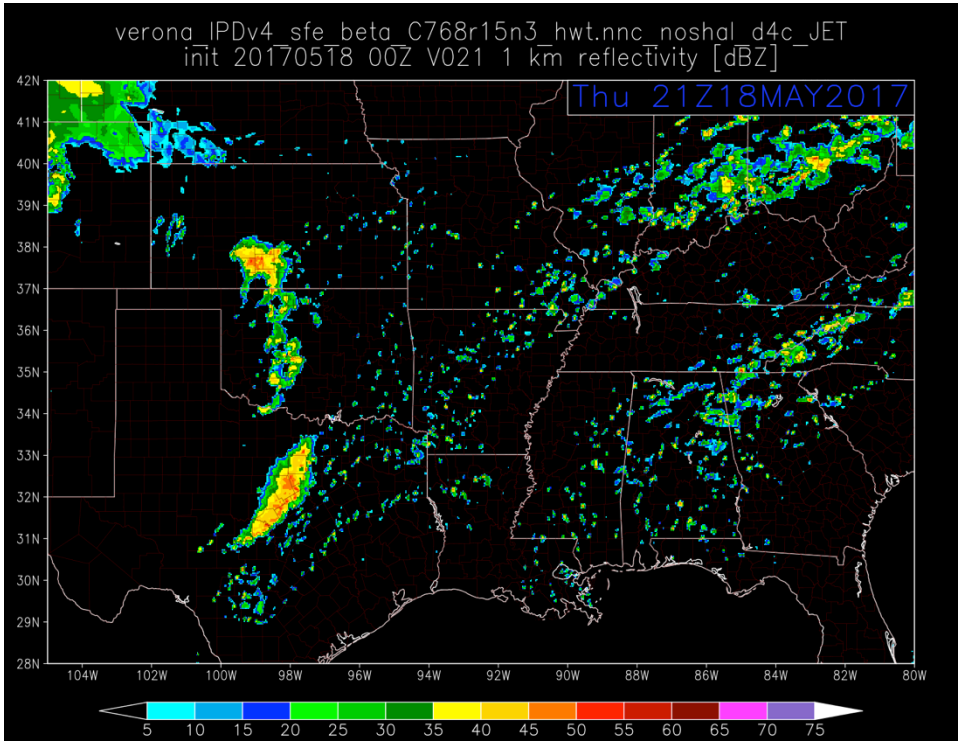
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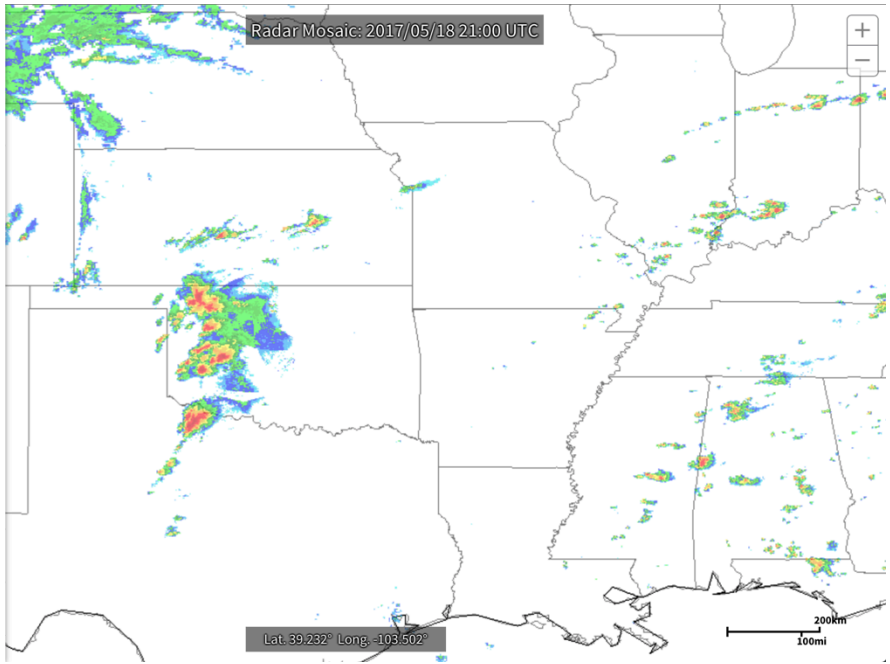
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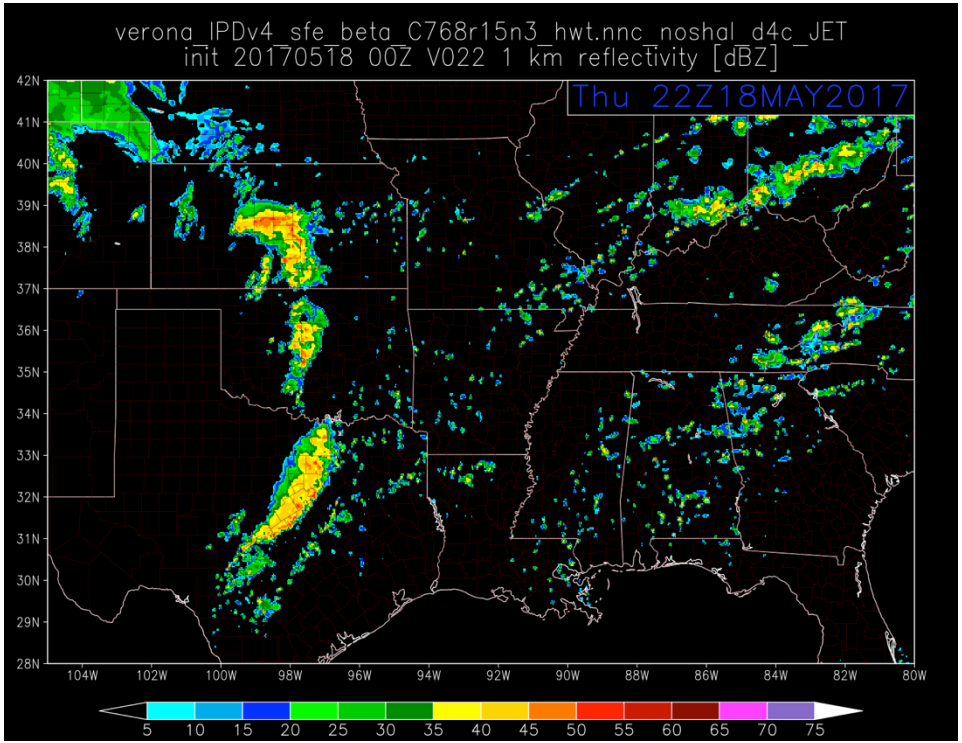
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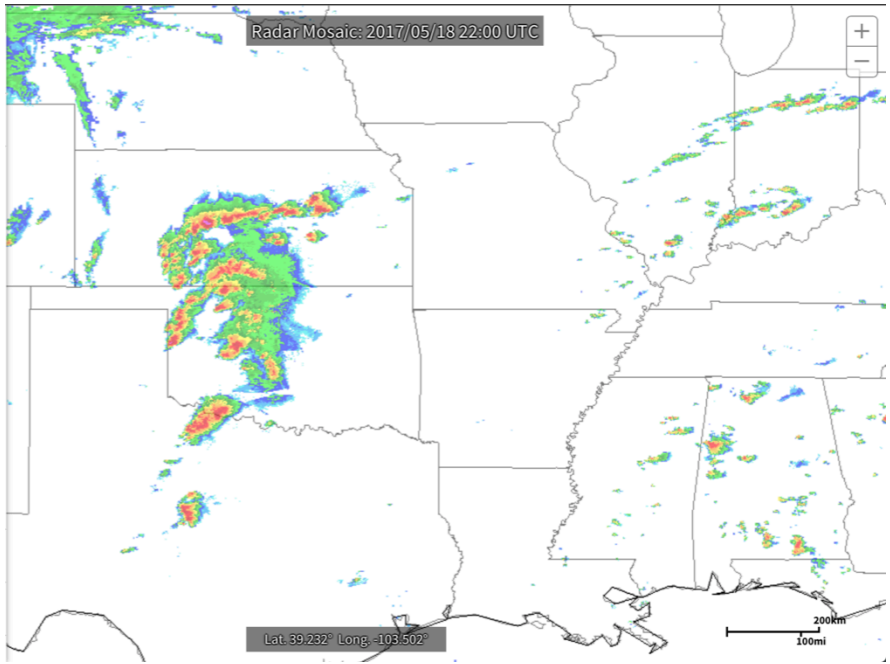
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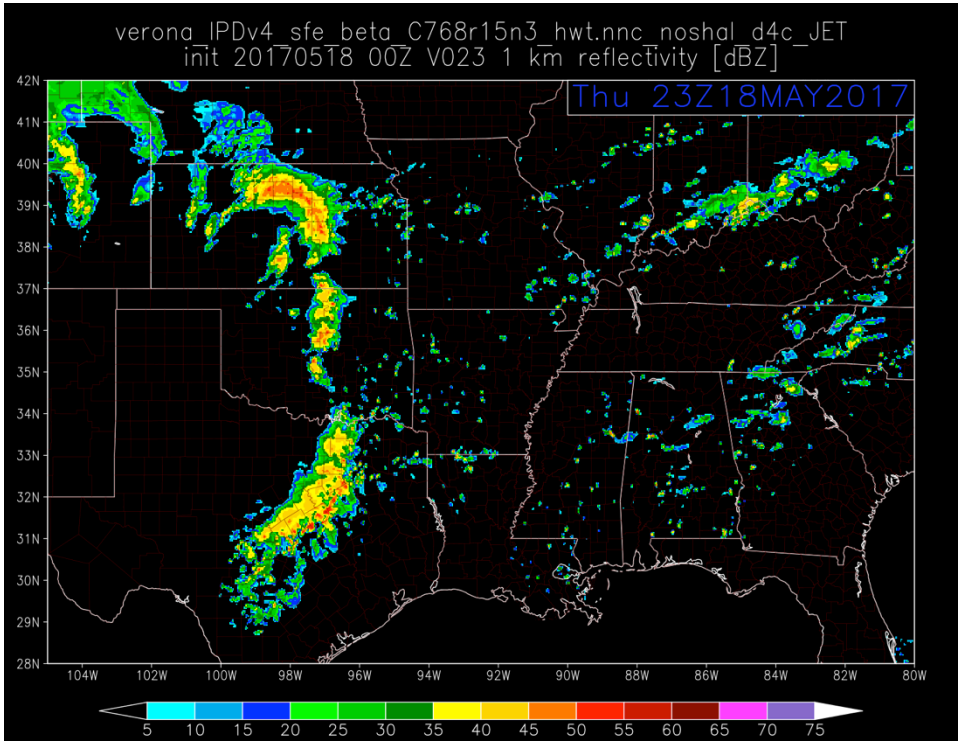
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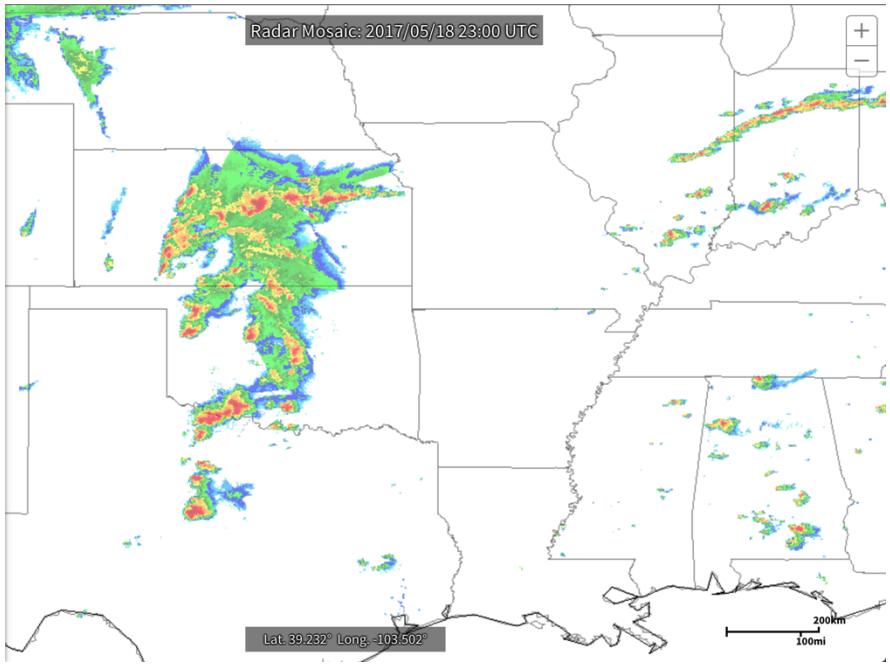
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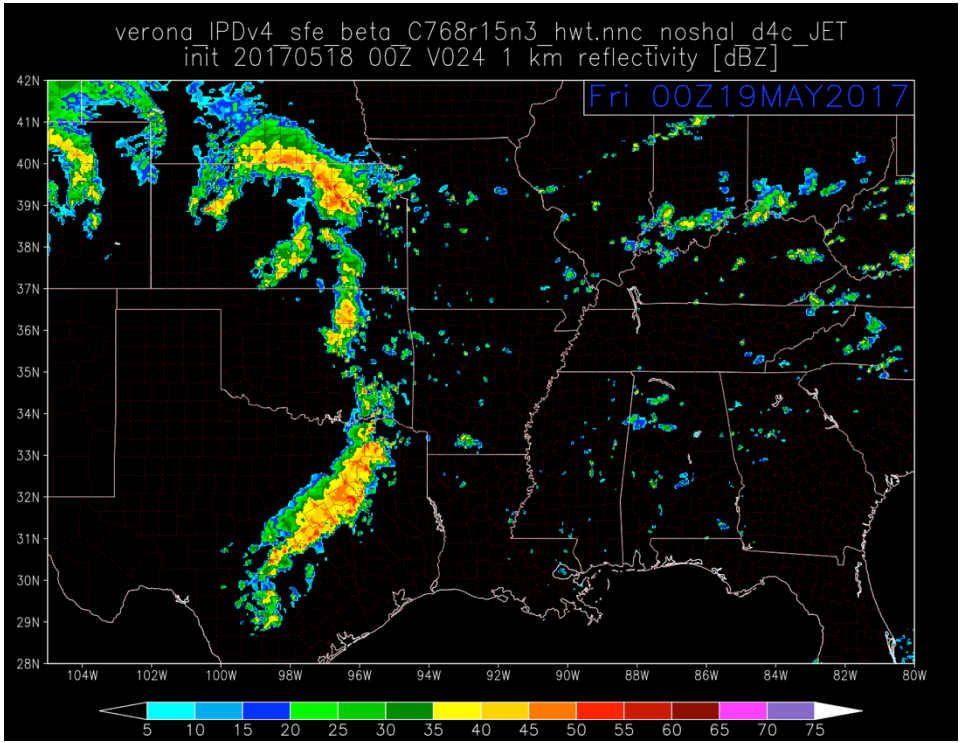
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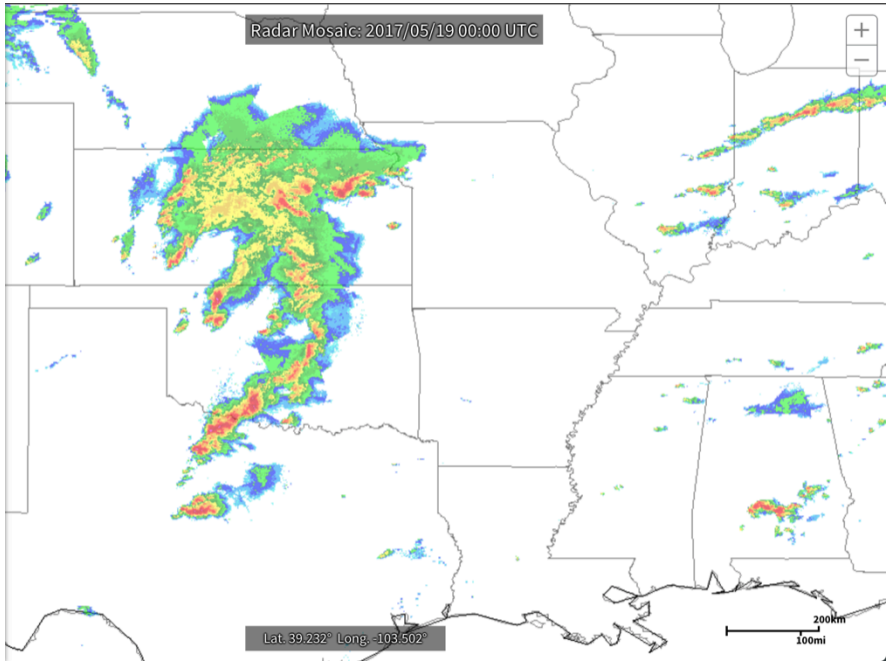
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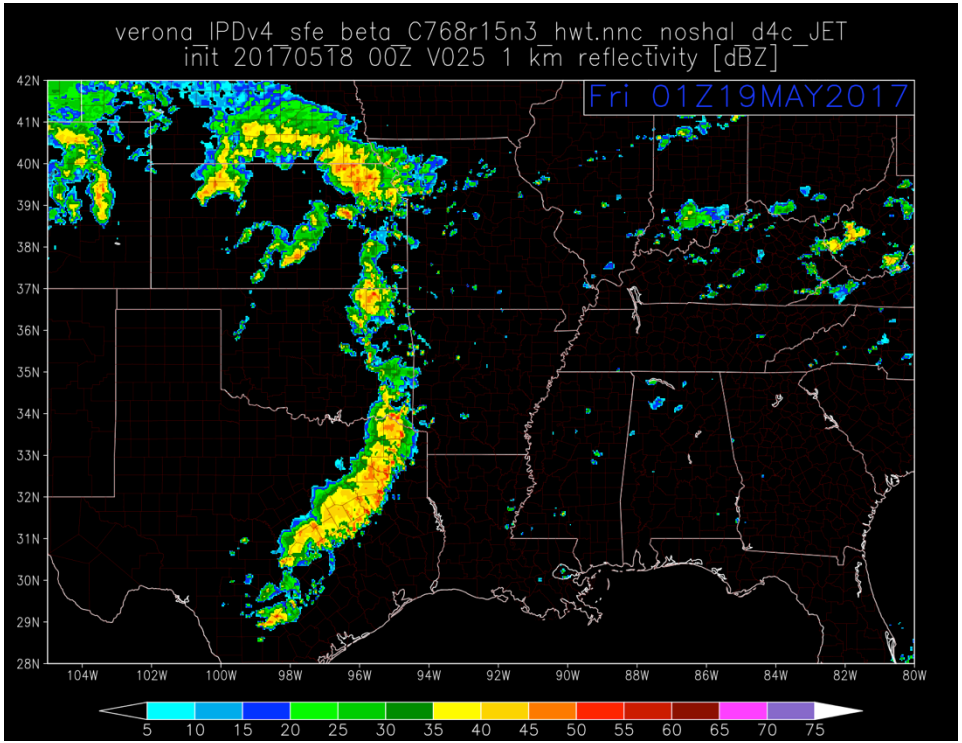
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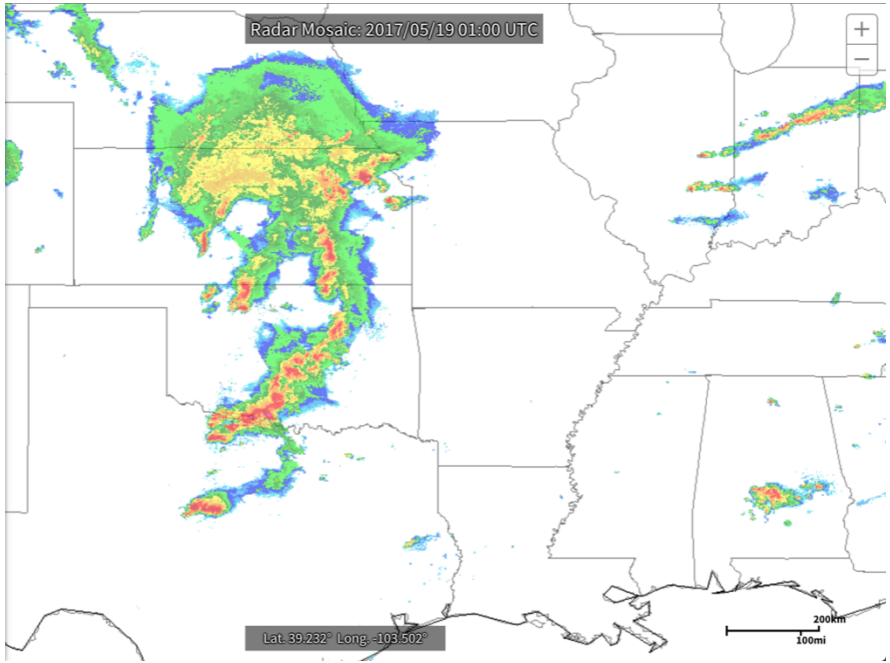
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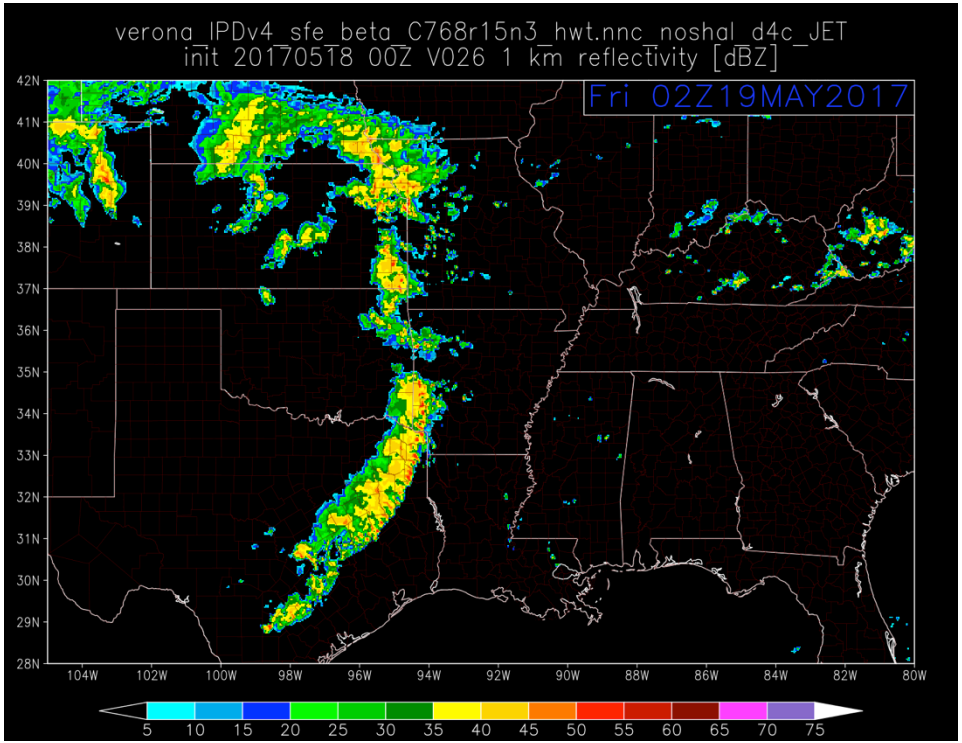
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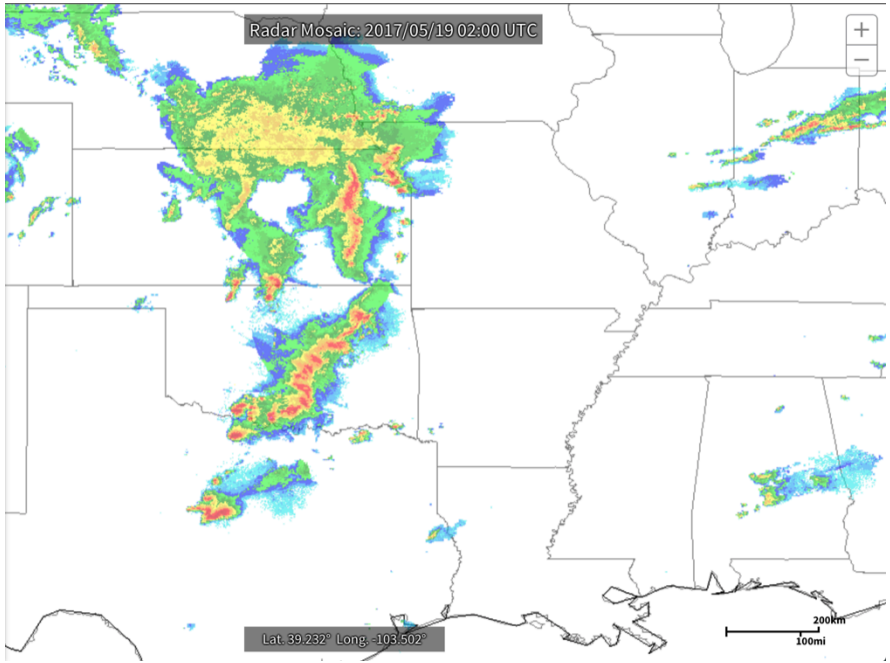
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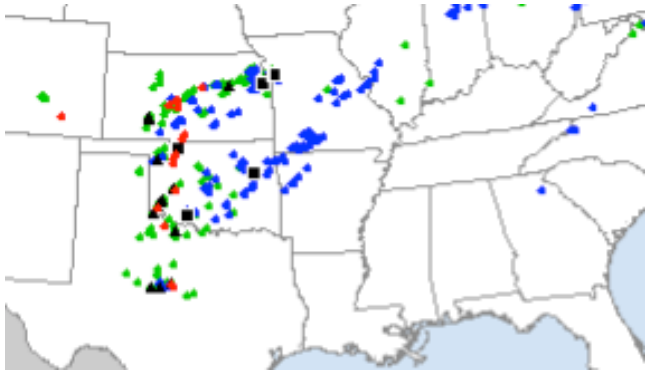
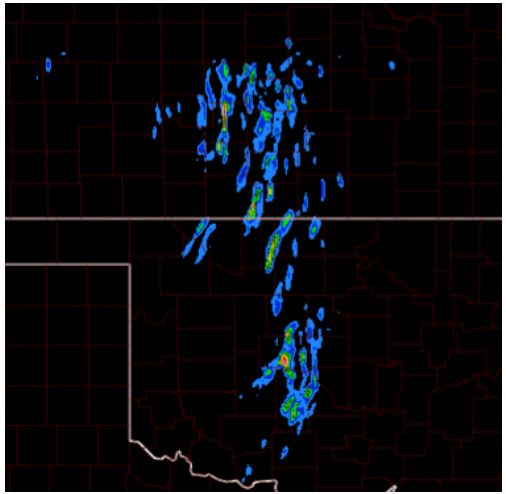
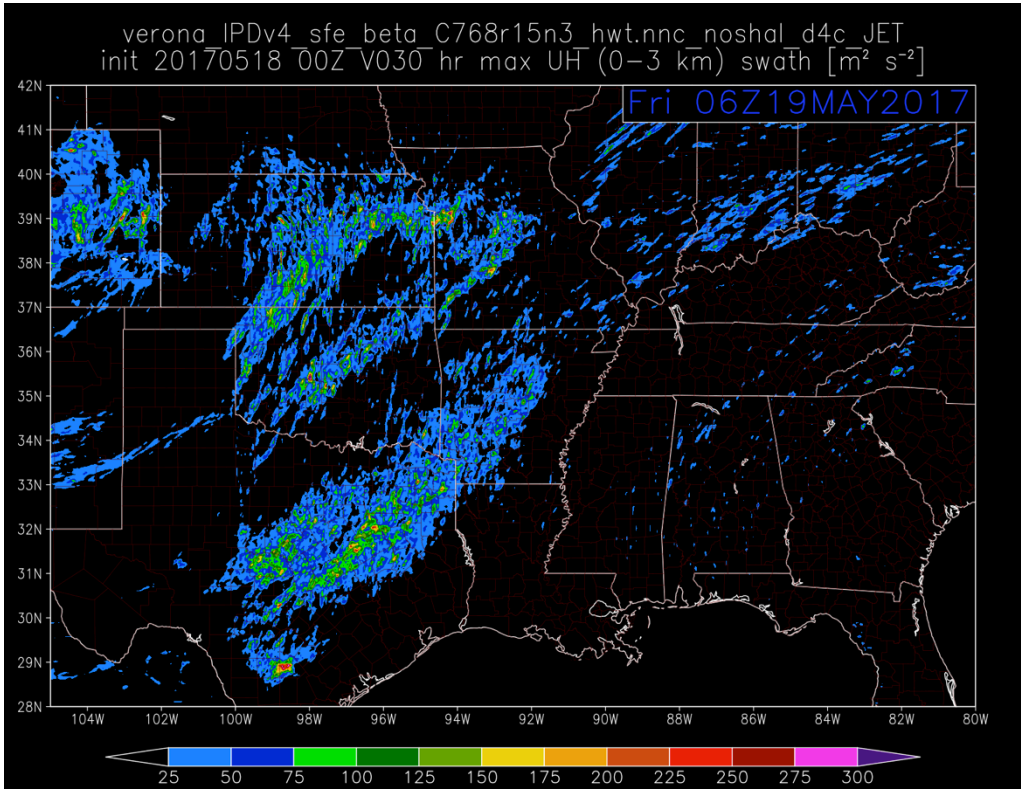


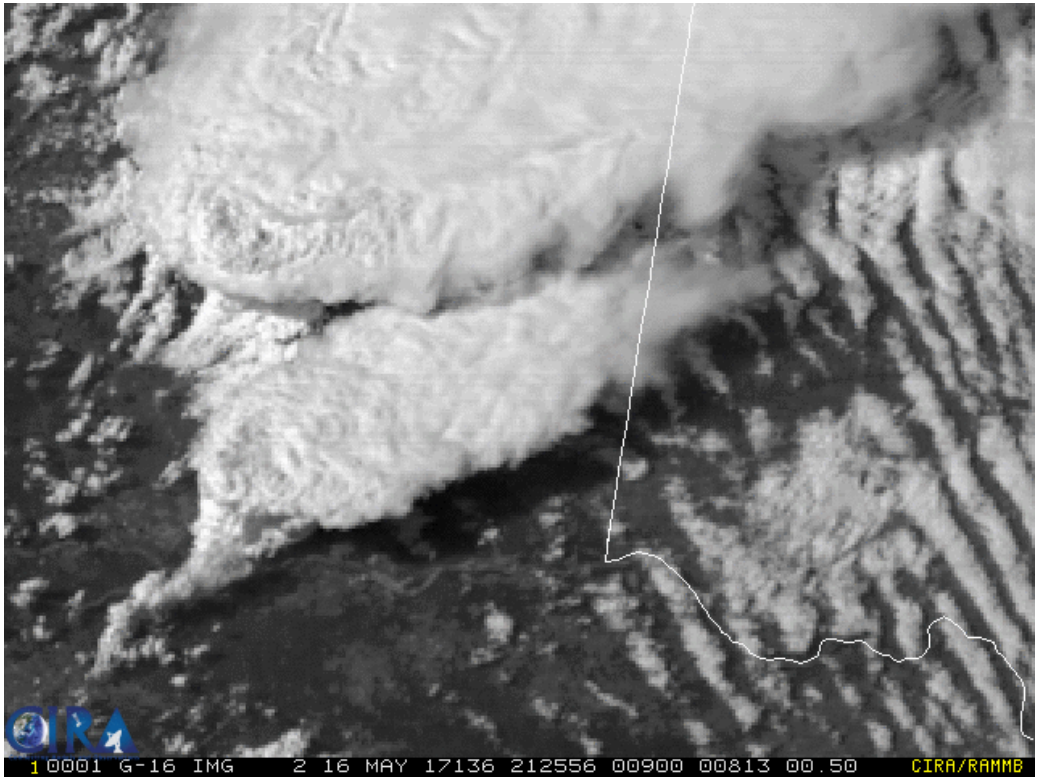


22Z

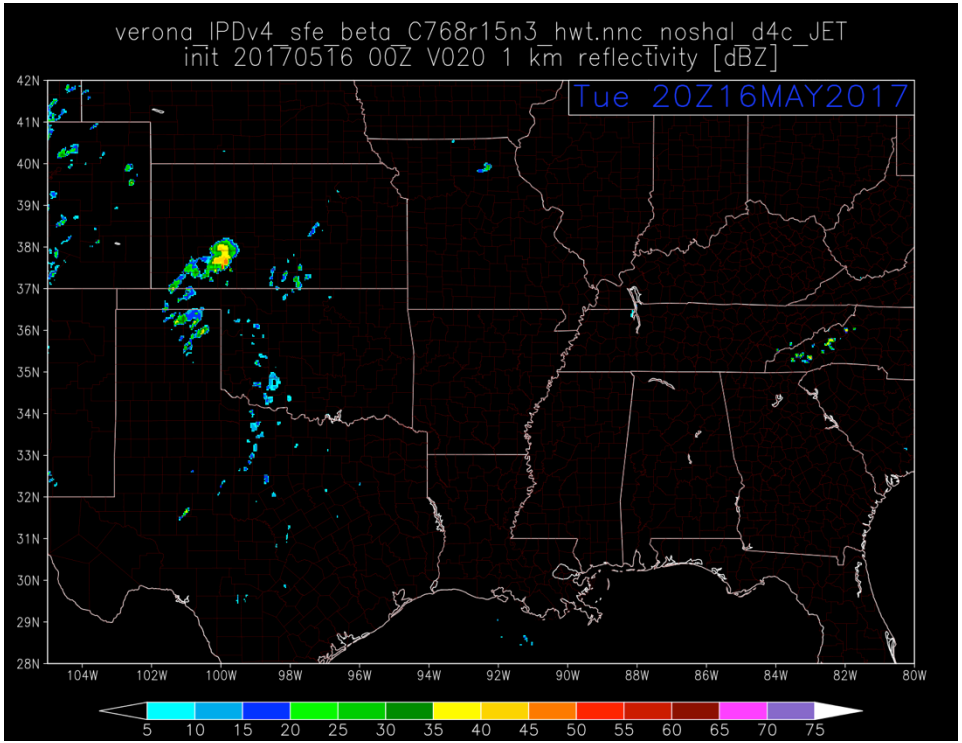


0-3 km UH; 2-5 km (HWT website) are more intense

16 May TX-OK outbreak



GOES-16 1-min band 2 visible:
Rotating supercells and roll clouds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41N
40N
39N
38N
37N
36N
35N
34N
33N
32N
31N
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29N
28N
104W
102W
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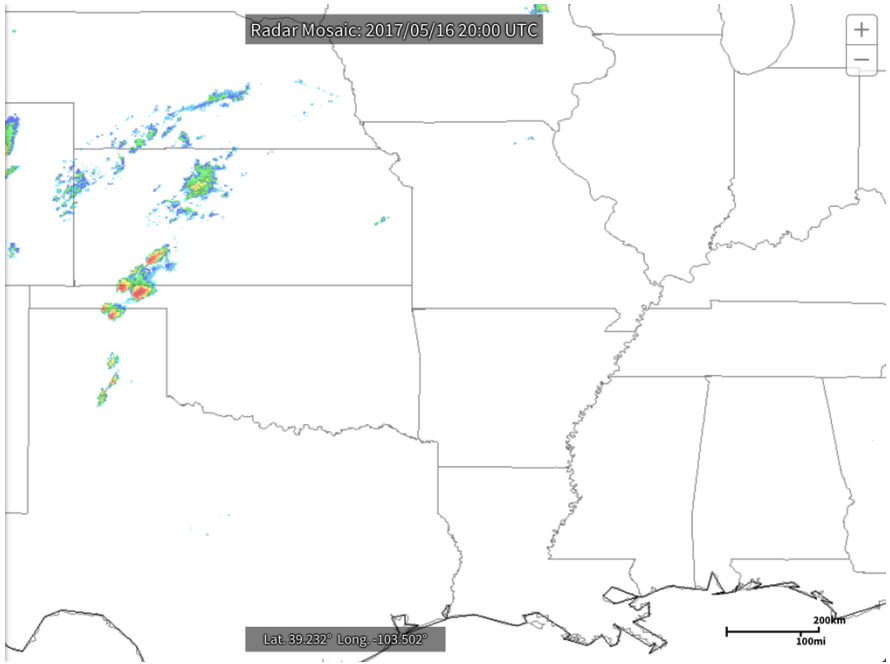
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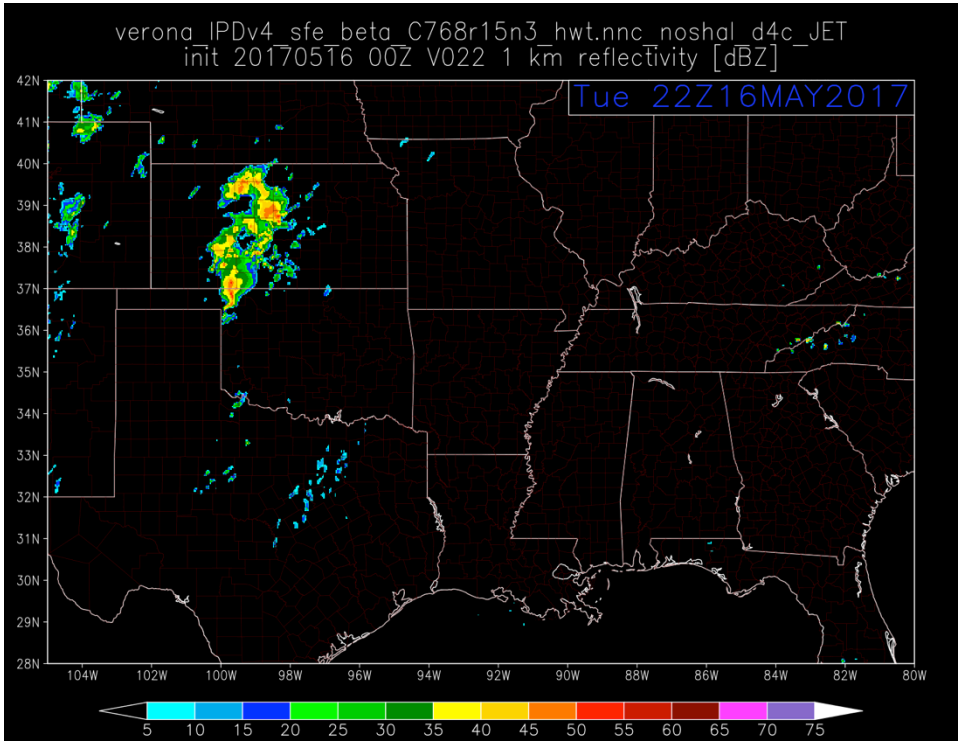
200km
100mi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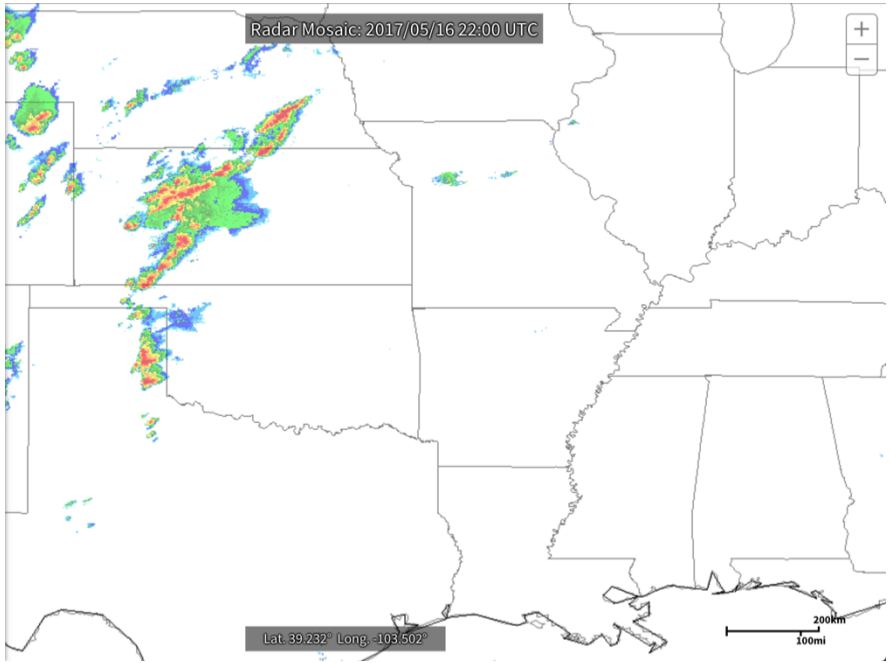
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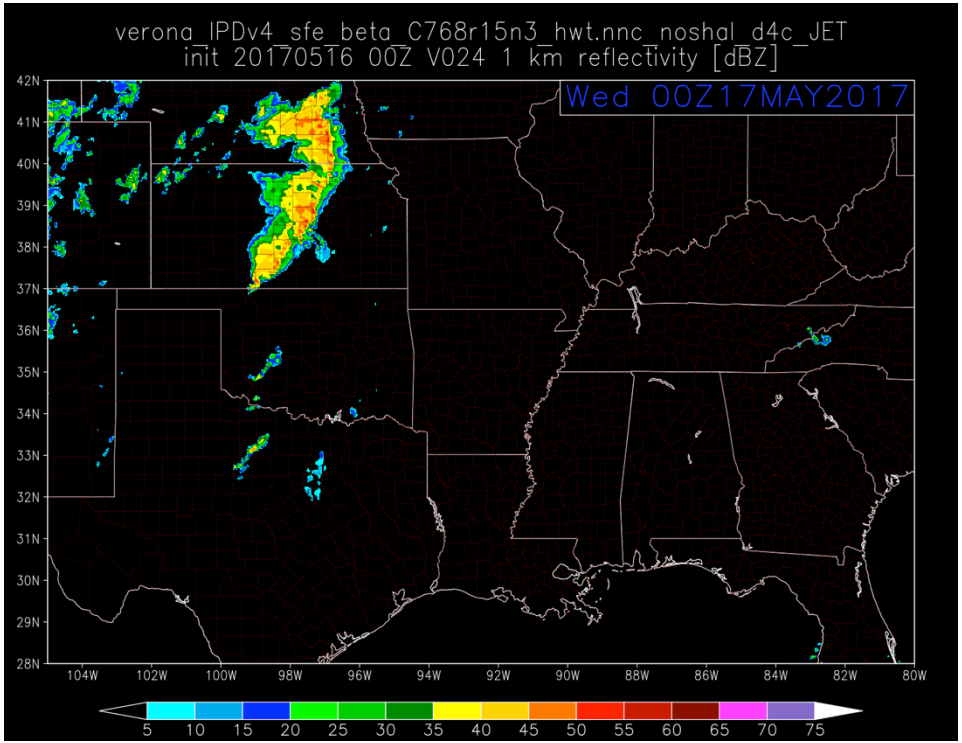
200km
100mi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Wed 00Z17MAY2017
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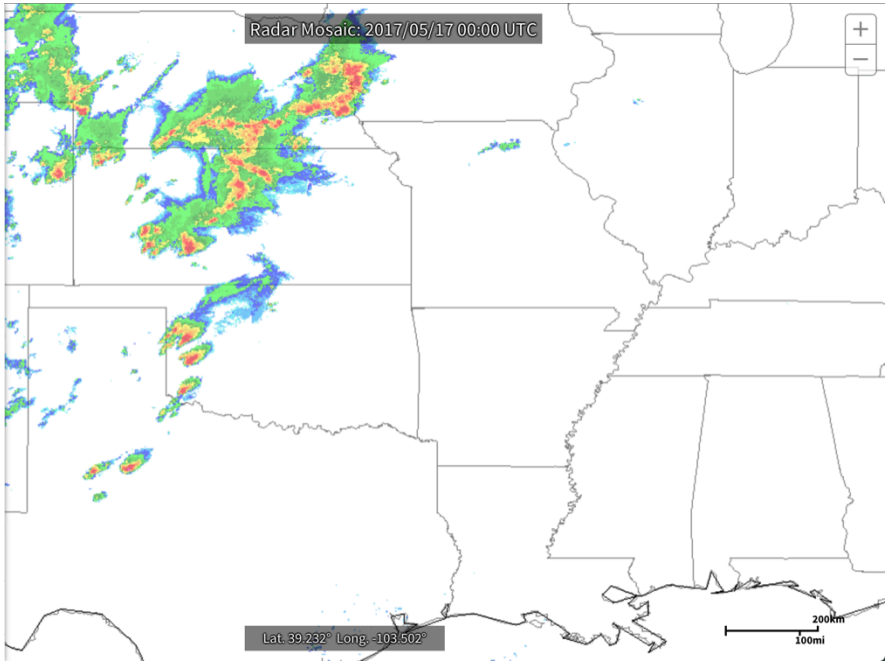
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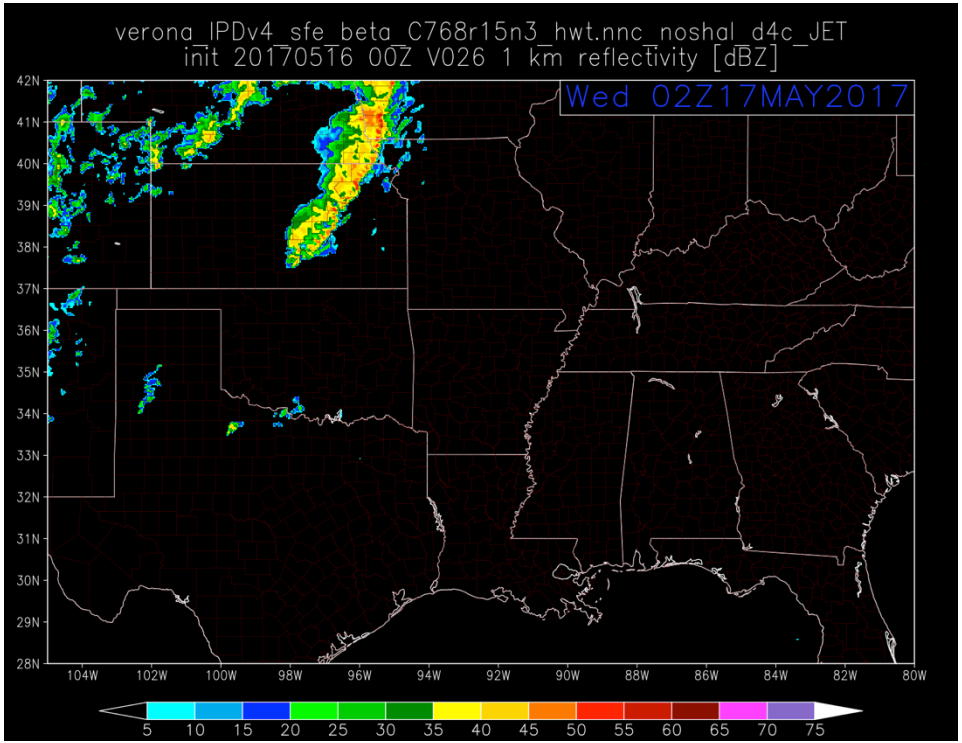
200km
100mi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Wed 02Z17MAY2017
42N
41N
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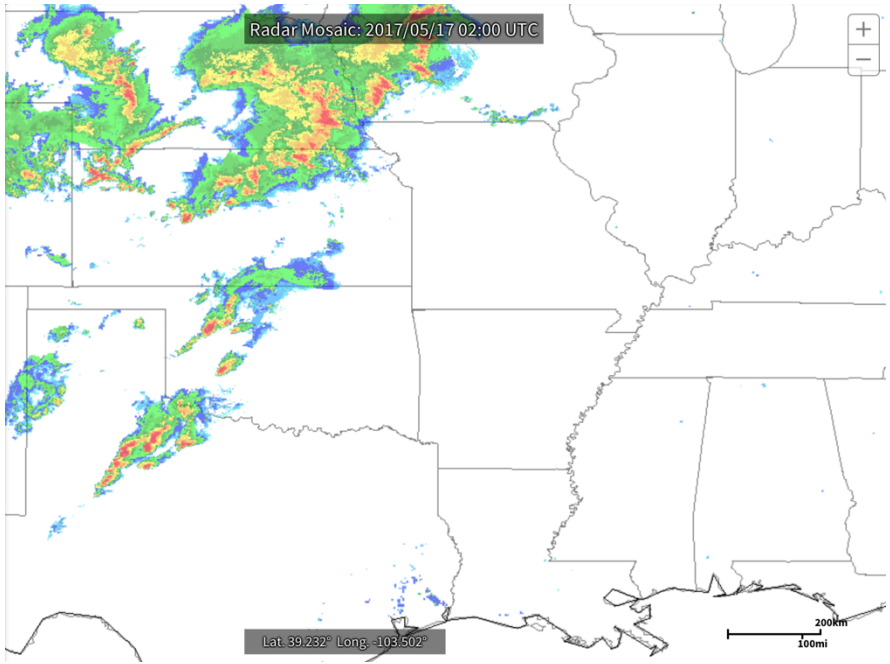
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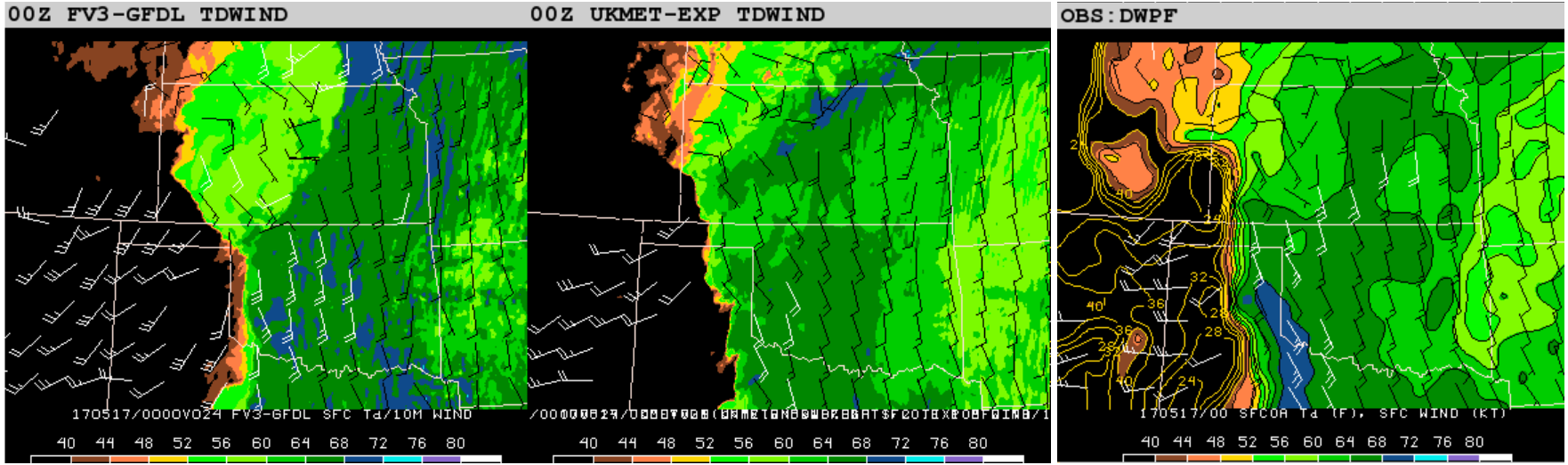
100mi



Dryline erodes very quickly in fvGFS.
Likely a deficiency in PBL scheme.

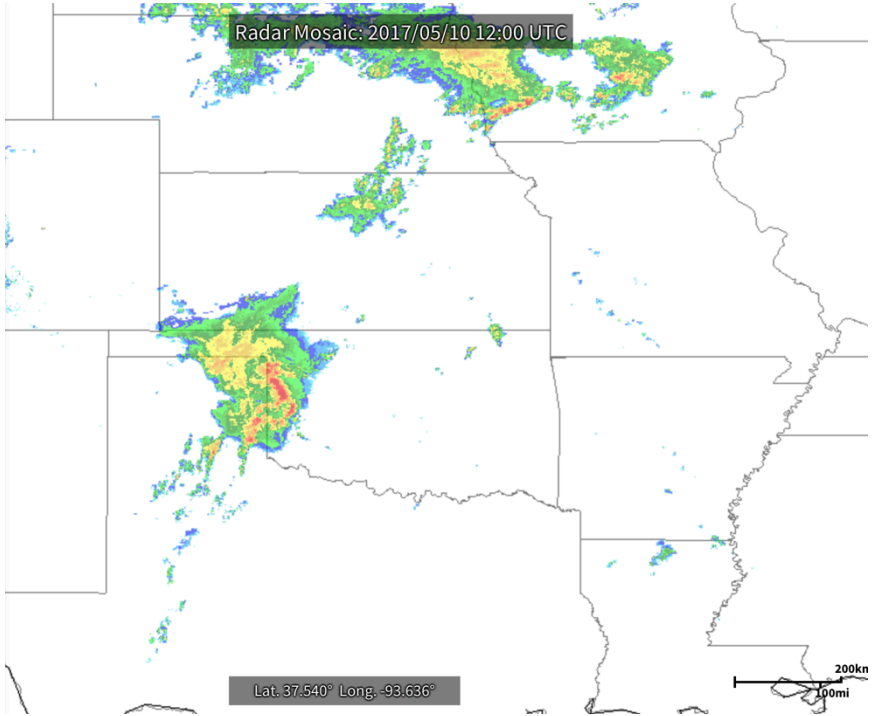
NASA GEOS-5 at C3072 (3-km)

GEOS-5 uses the UKMO Lock PBL scheme for convective situation and the Louis (old ECMWF scheme) for stable condition; the cloud MP is by Bacmeister.

Extended range prediction
10 May Storms

Radar validation

12UTC 10 May 2017



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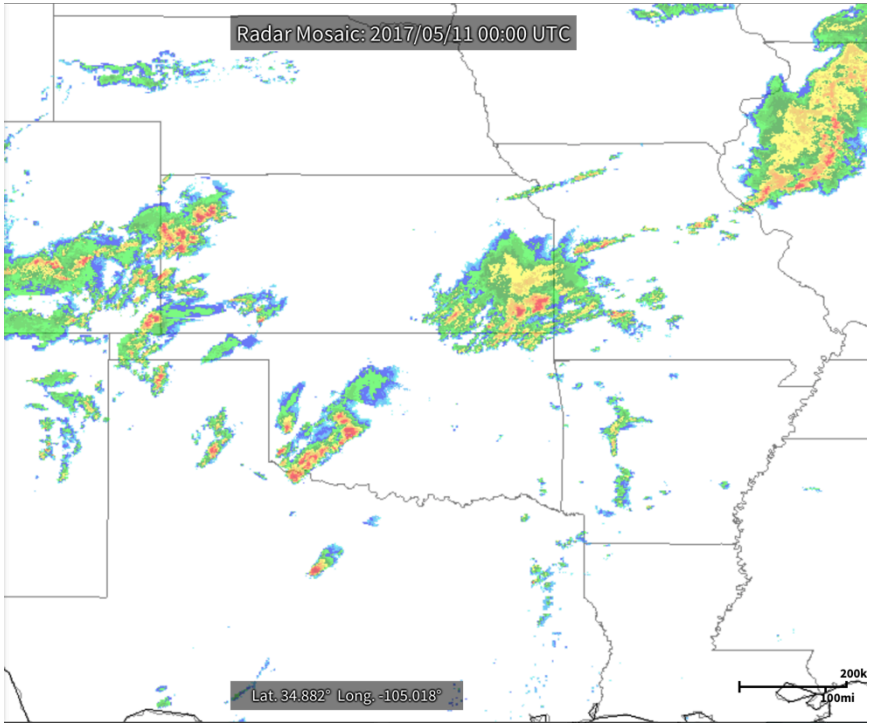
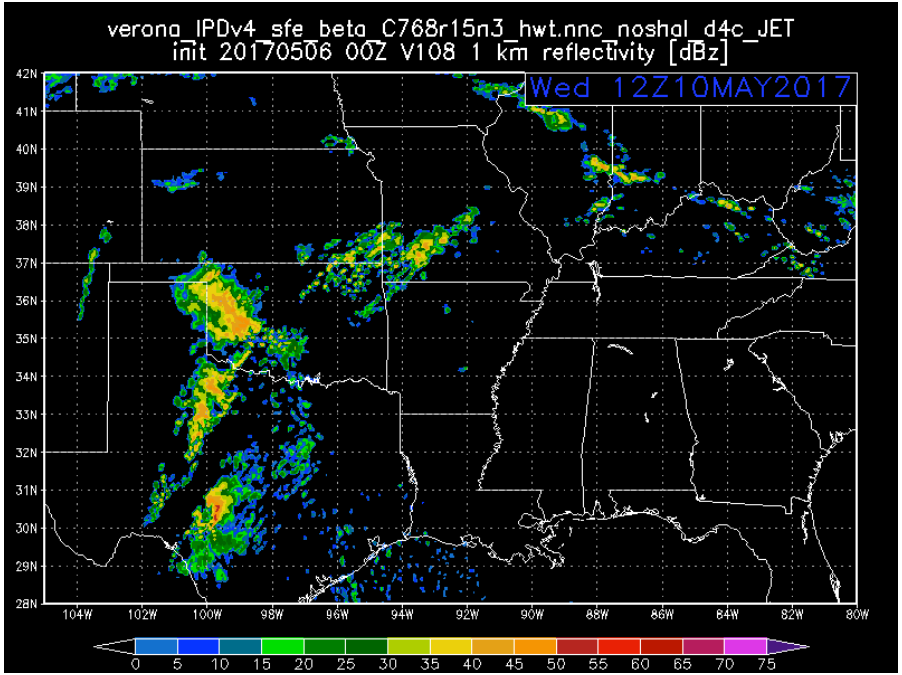


Init 0506 00Z

12UTC 10 May 2017 +108h



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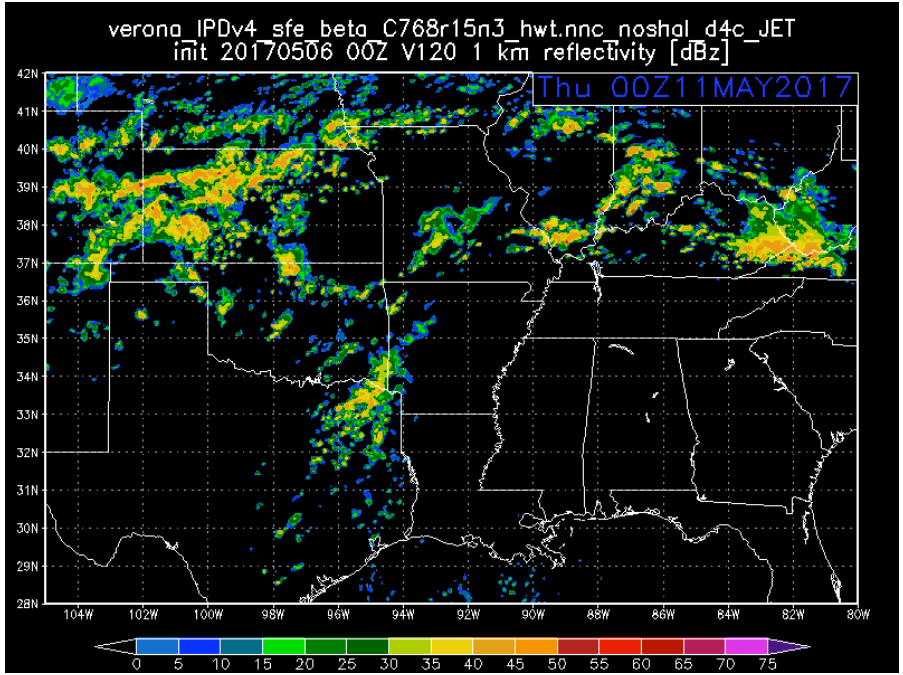

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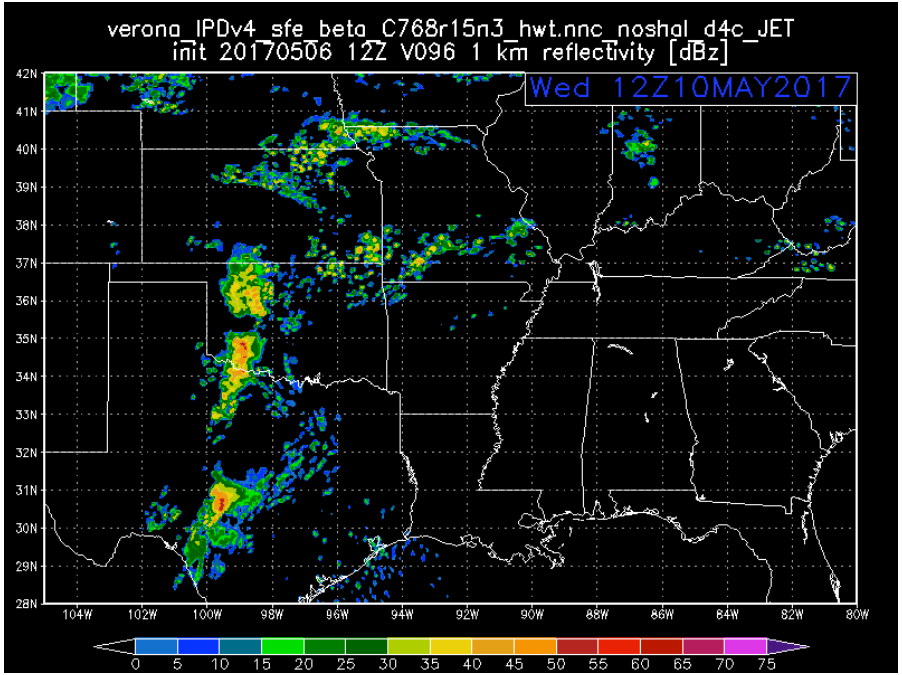
12UTC 10 May 2017 +096h



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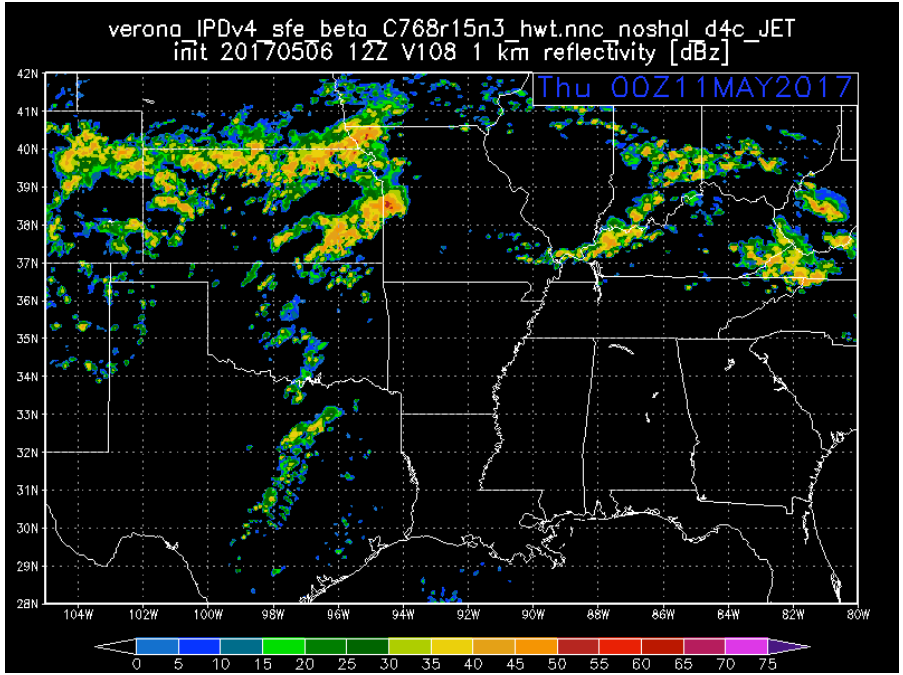

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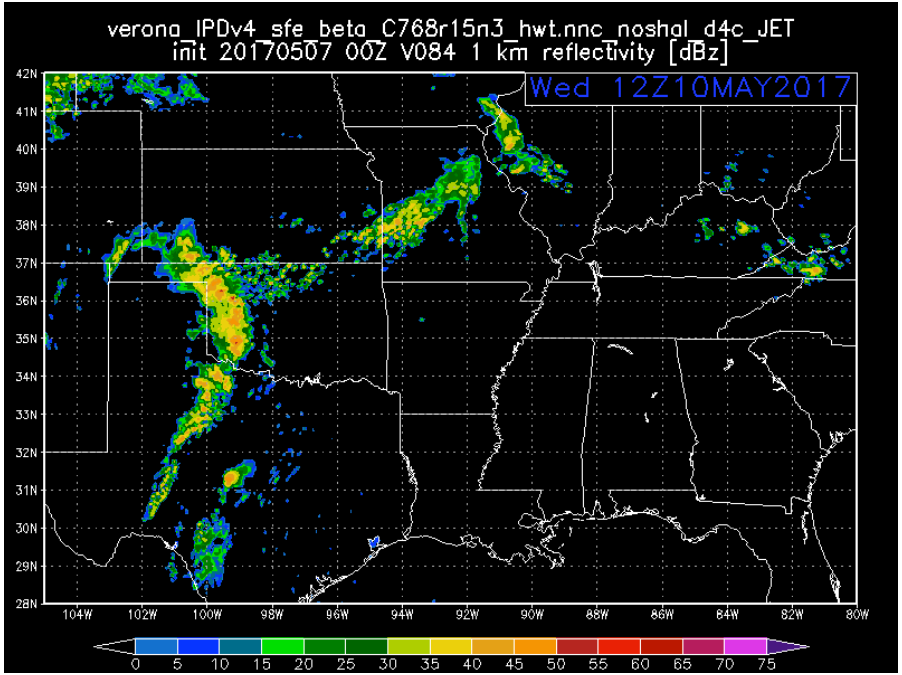

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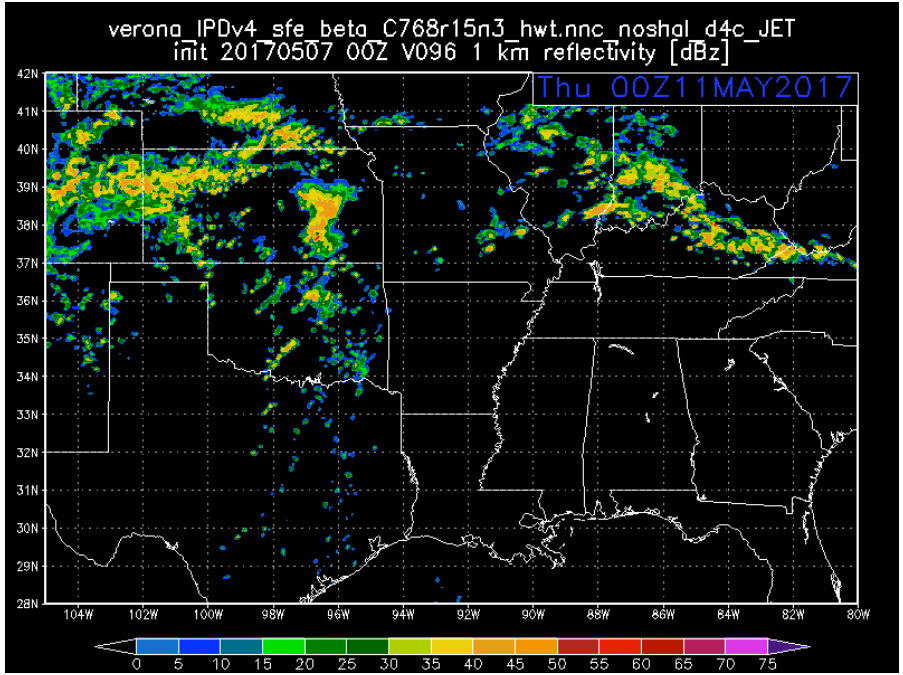

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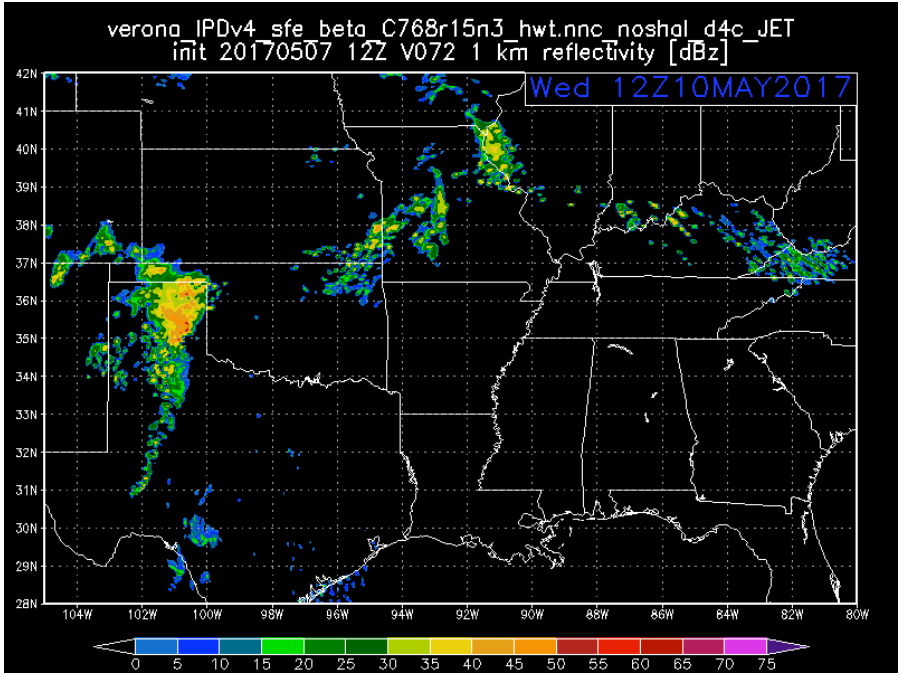

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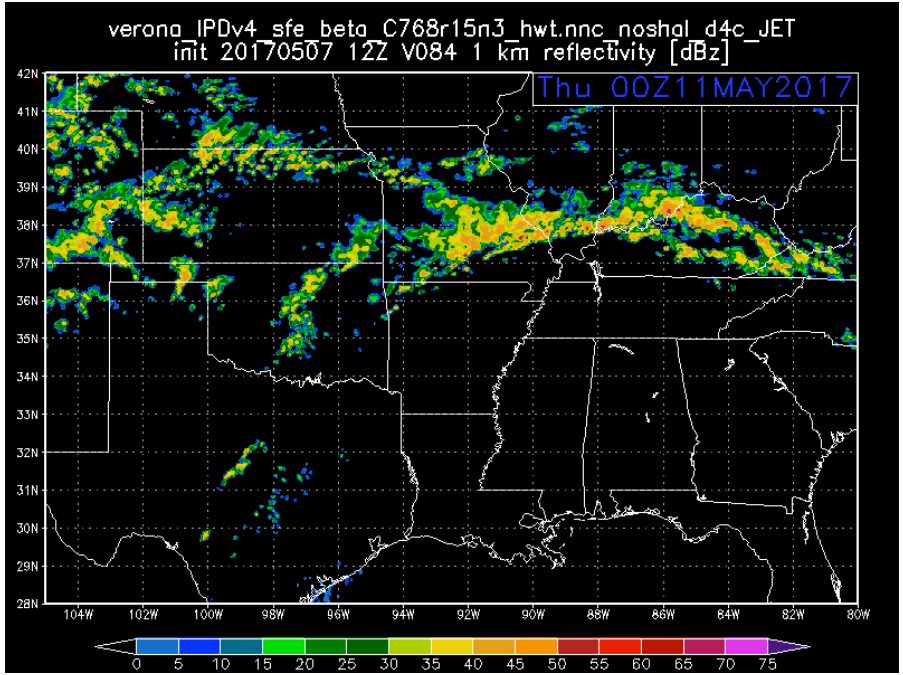

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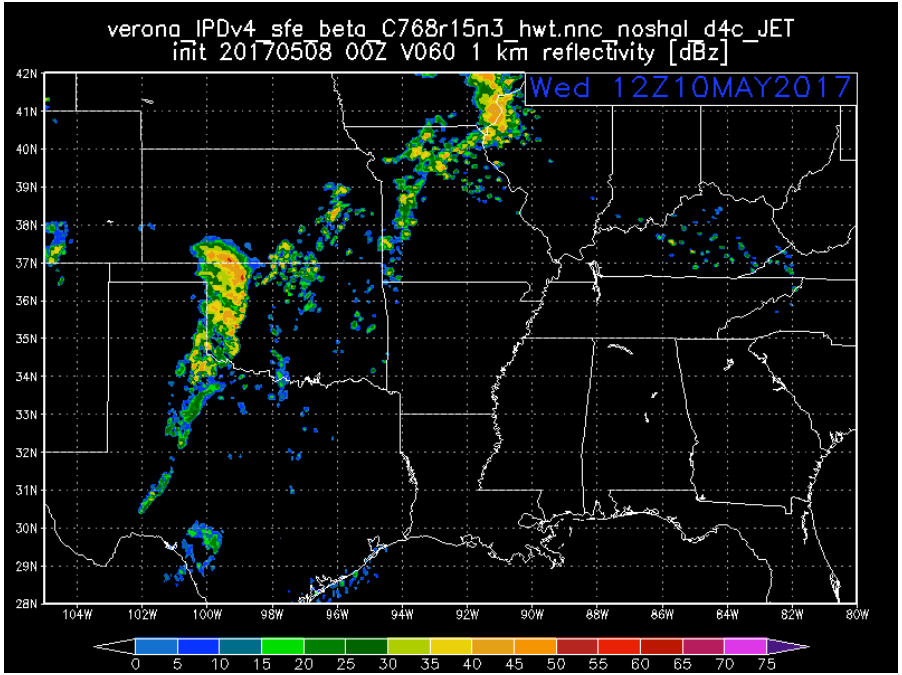

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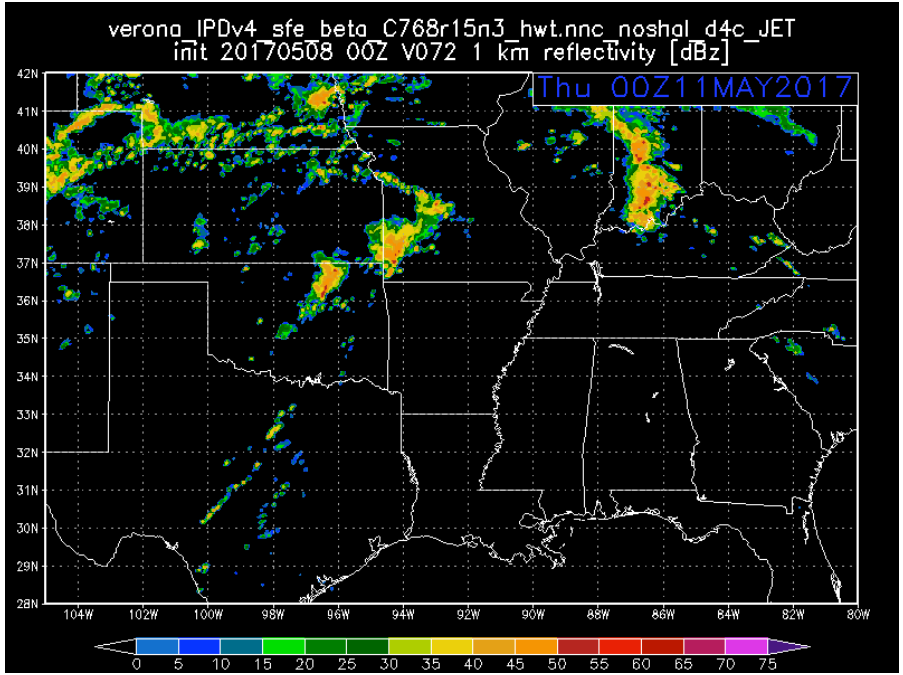

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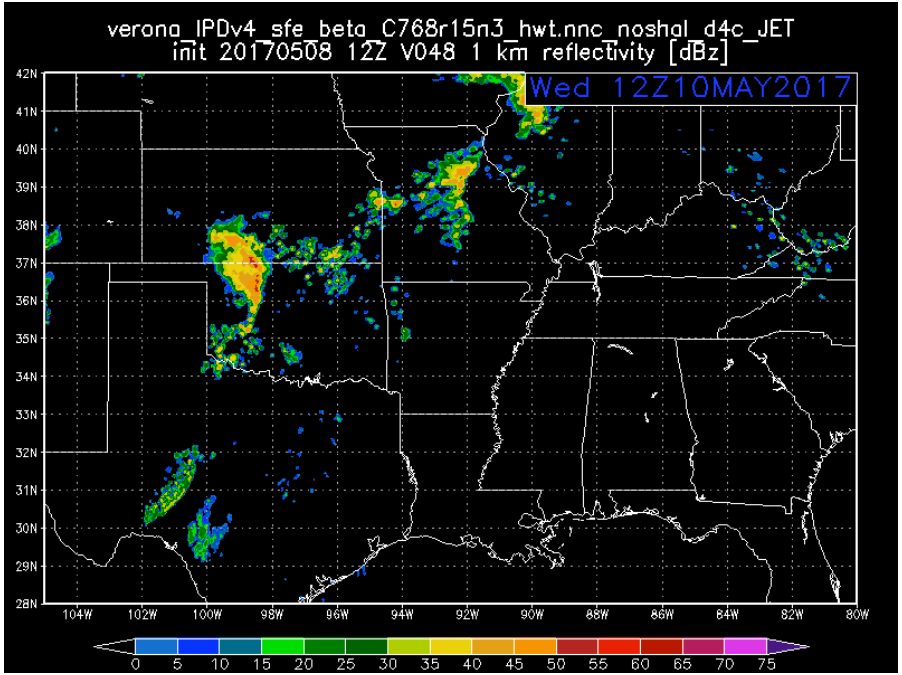

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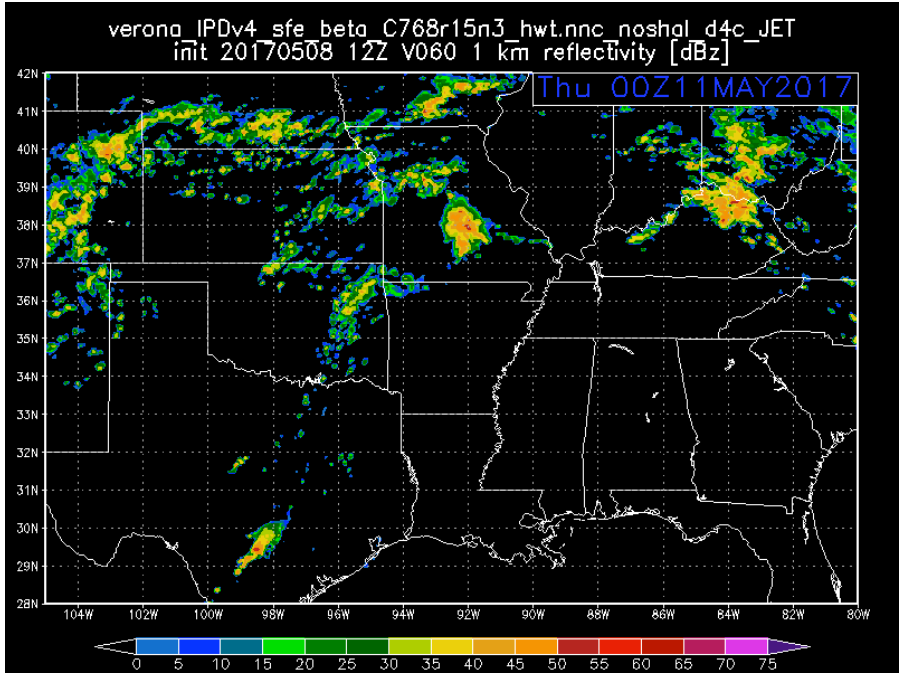
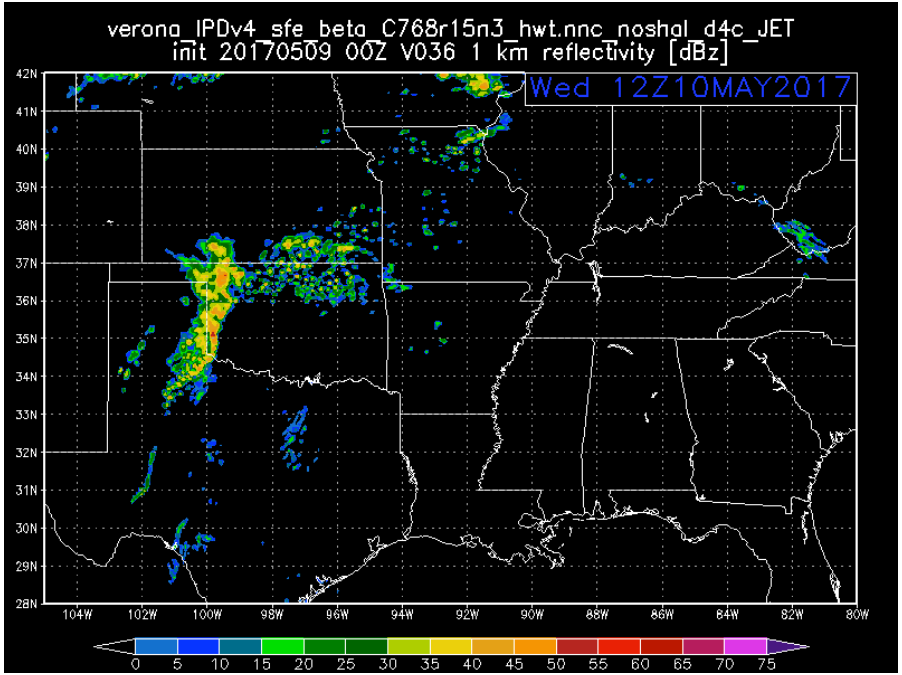


Init 0509 00Z

12UTC 10 May 2017 +036h



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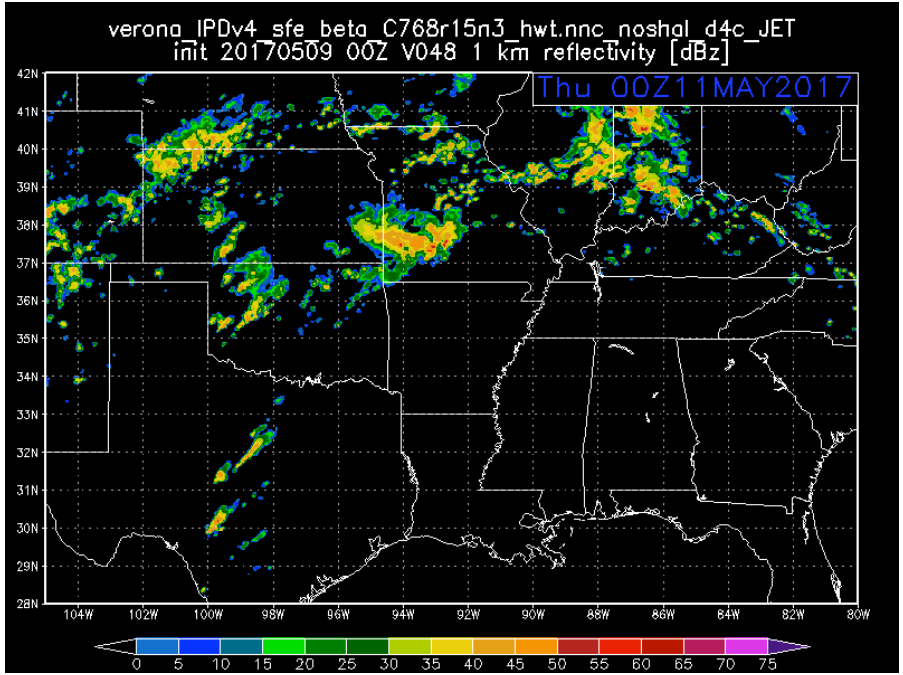

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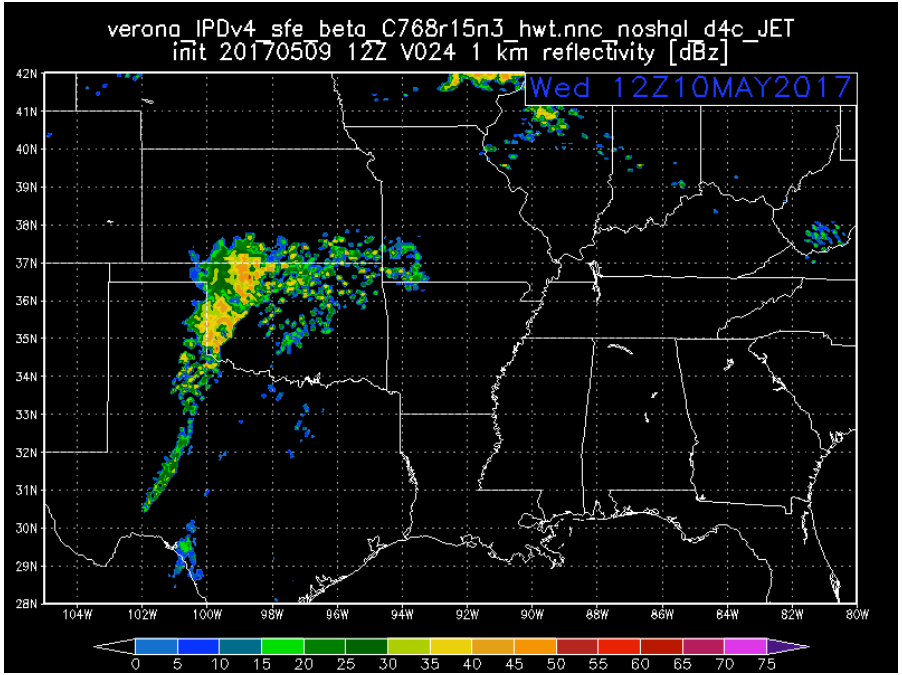

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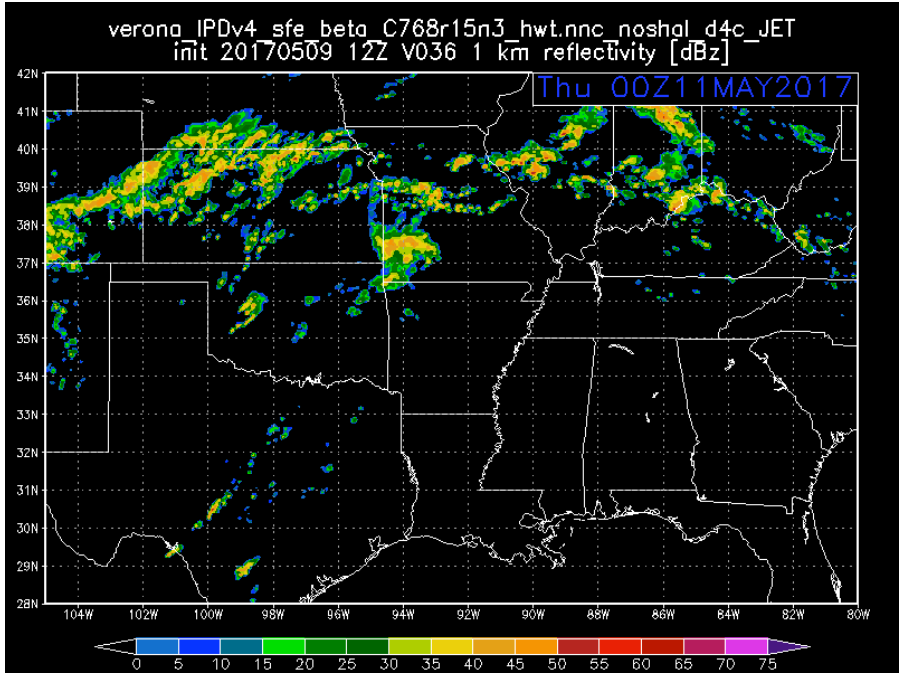
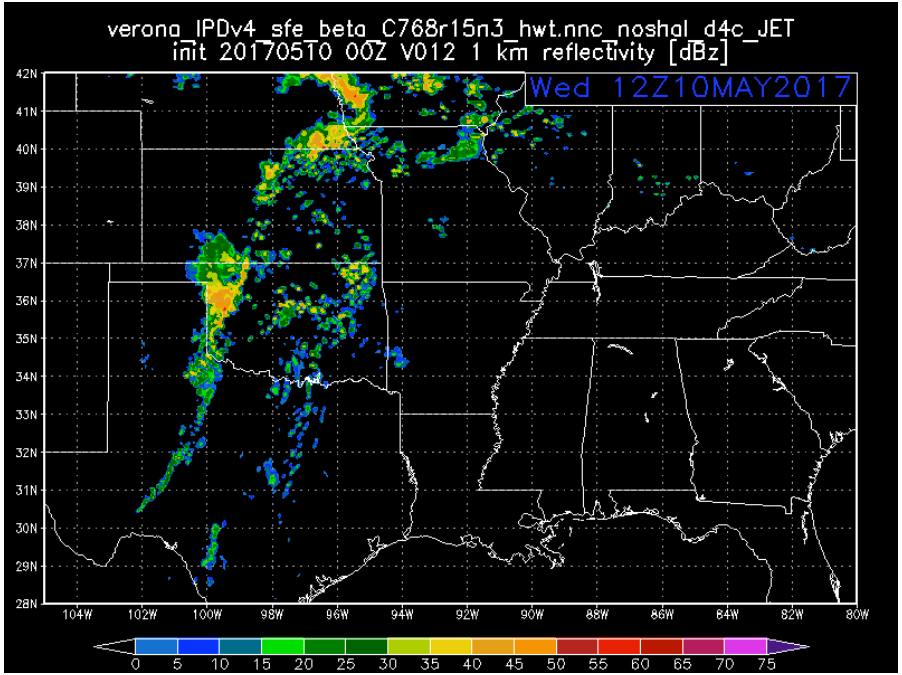


Init 0510 00Z

12UTC 10 May 2017 +012h



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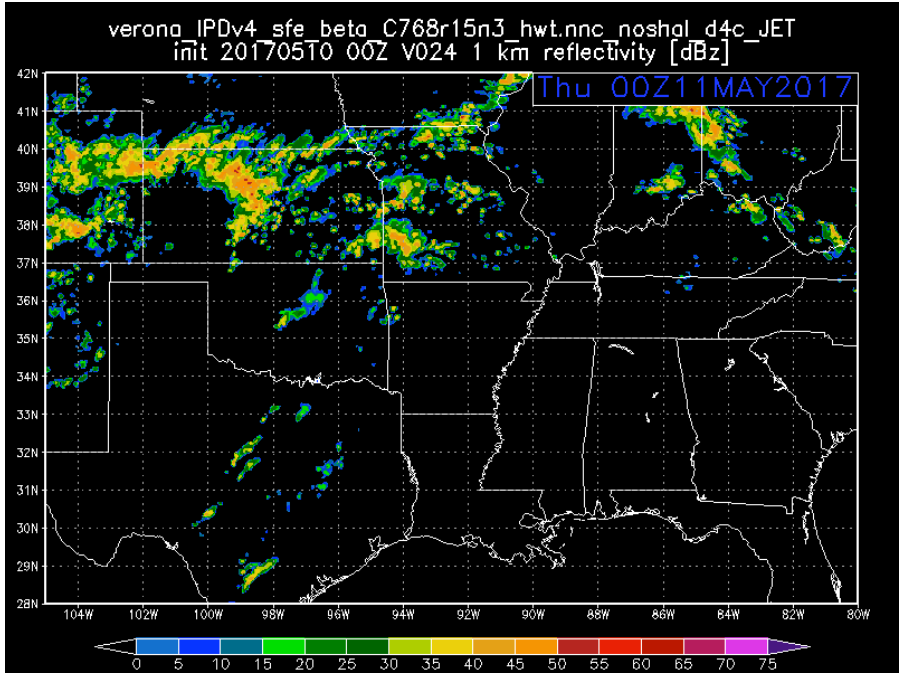
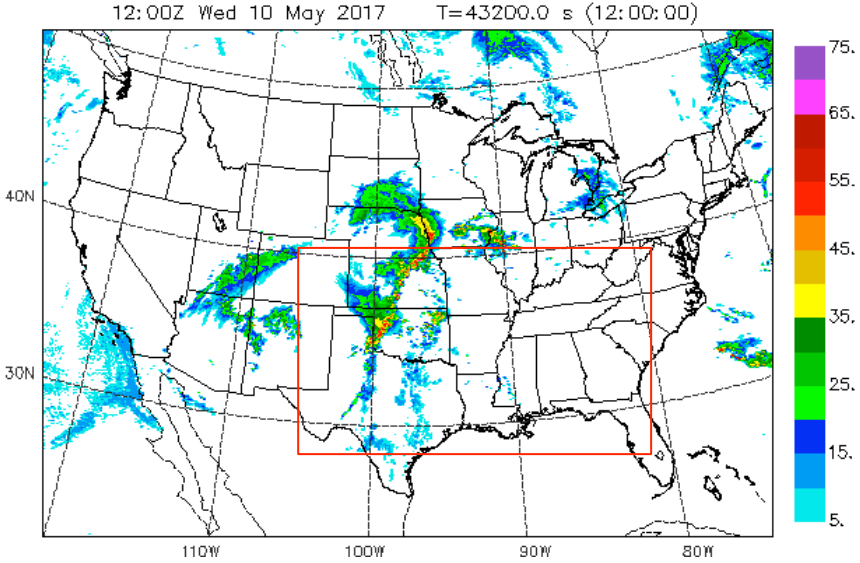


Composite Reflectivity from FV3-CAPS

Using Thompson MP: init 0510 00Z

12UTC 10 May 2017



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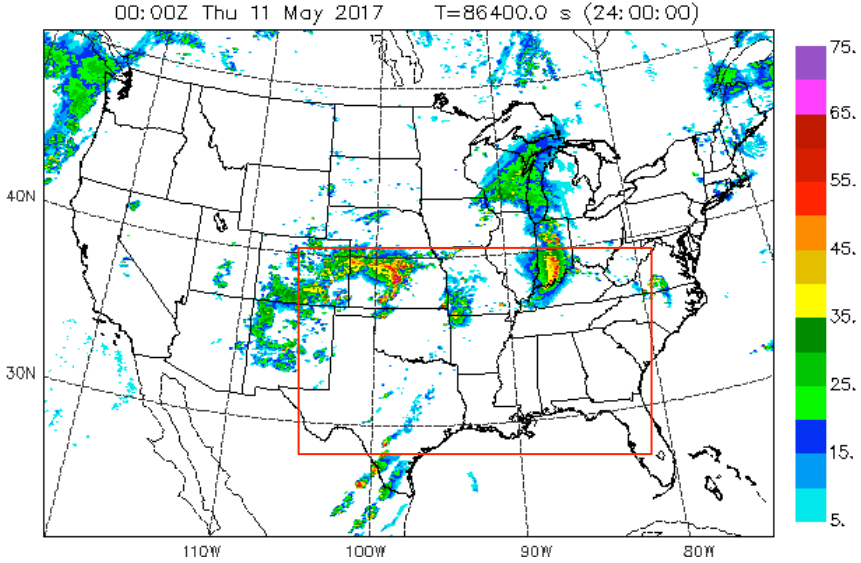
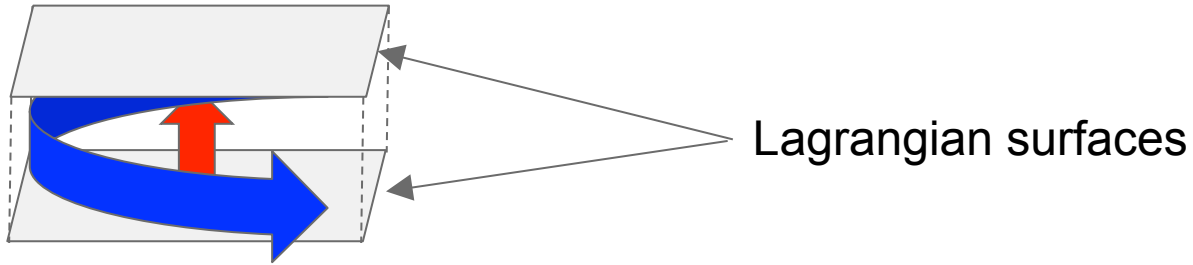


Updraft Helicity in fvGFS

FV^3 design is *optimal* for representing Updraft Helicity: *vertical vorticity* and ***vertical wind*** are co-located as “vertically Lagrangian” Finite-Volume mean

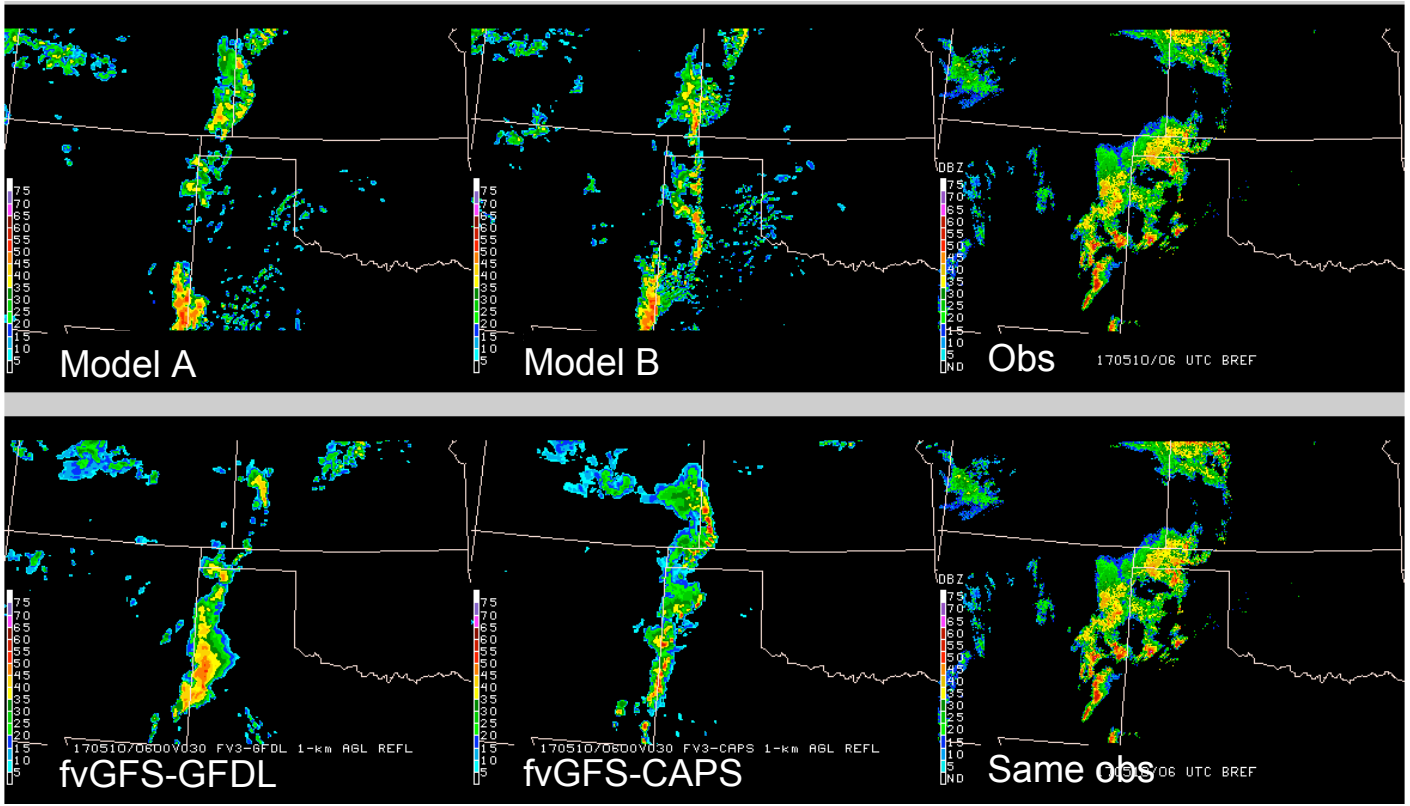


The Lagrangian control-volume is bounded vertically by 2 Lagrangian surfaces

- *Vertical wind is defined as volume-mean with edge values computed by a conservative cubic-spline reconstruction*
- *Vertical component of vorticity is also volume-mean as defined by the Stokes theorem (aka, the circulation theorem)*

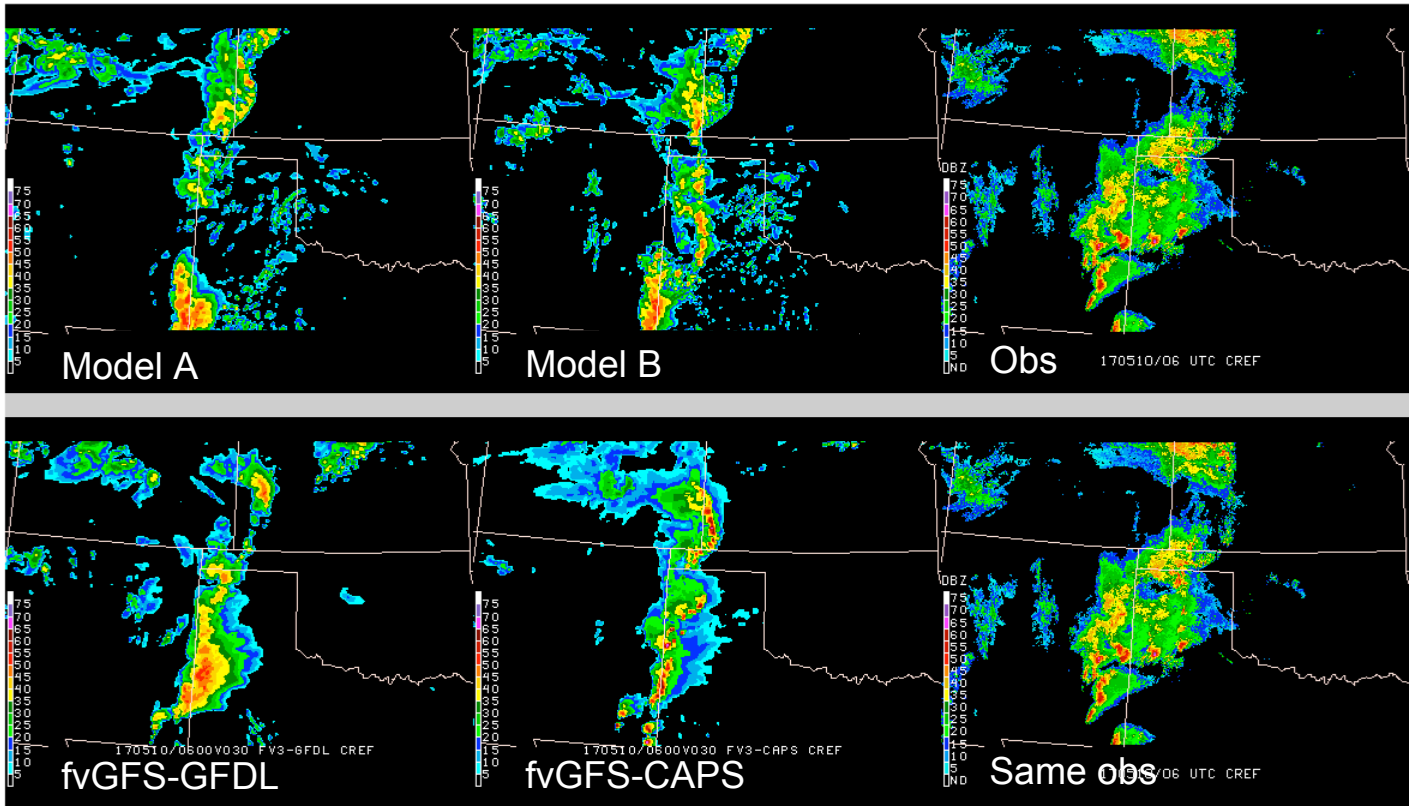
Base Reflectivity

+30 hr, init 00z 0510



Composite reflectivity

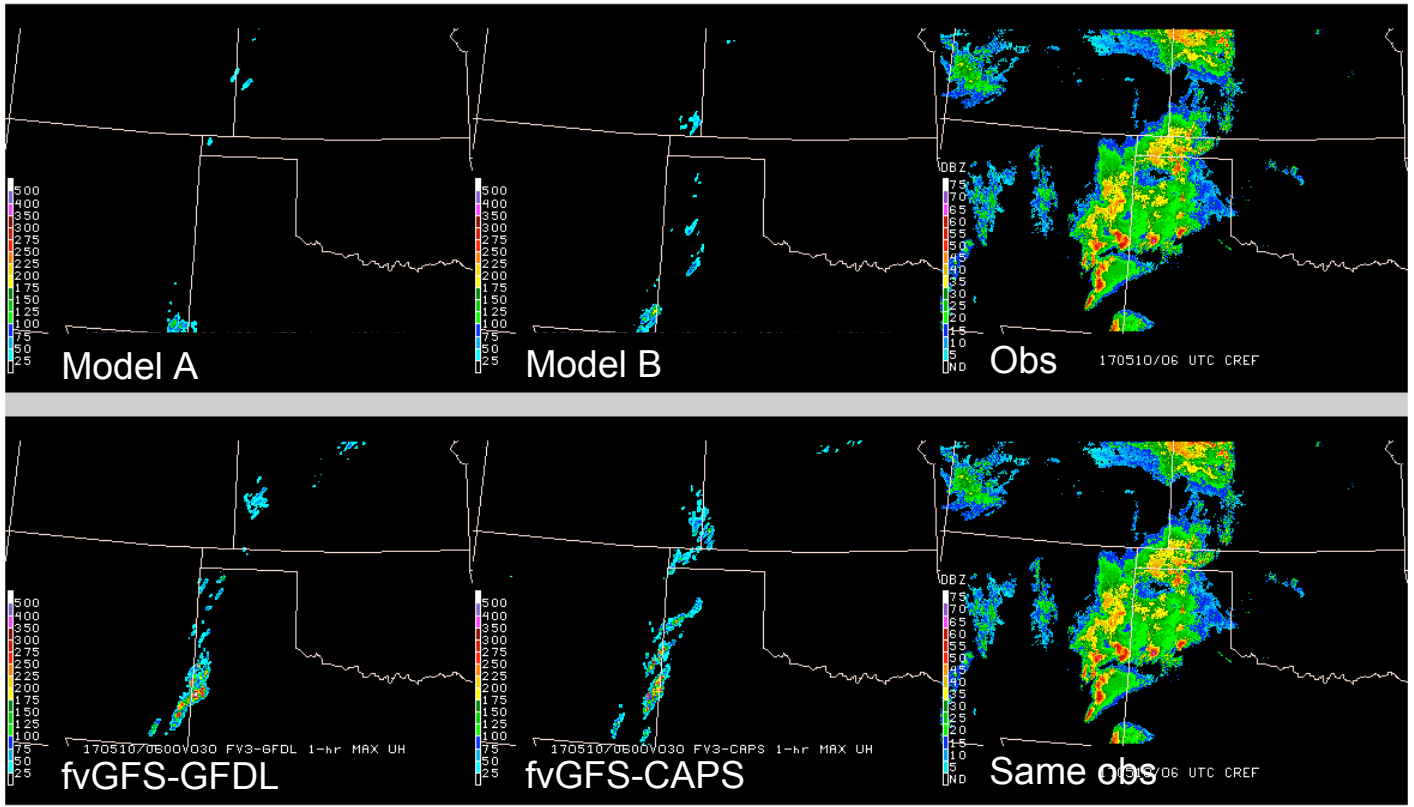
+30 hr, init 00z 0510



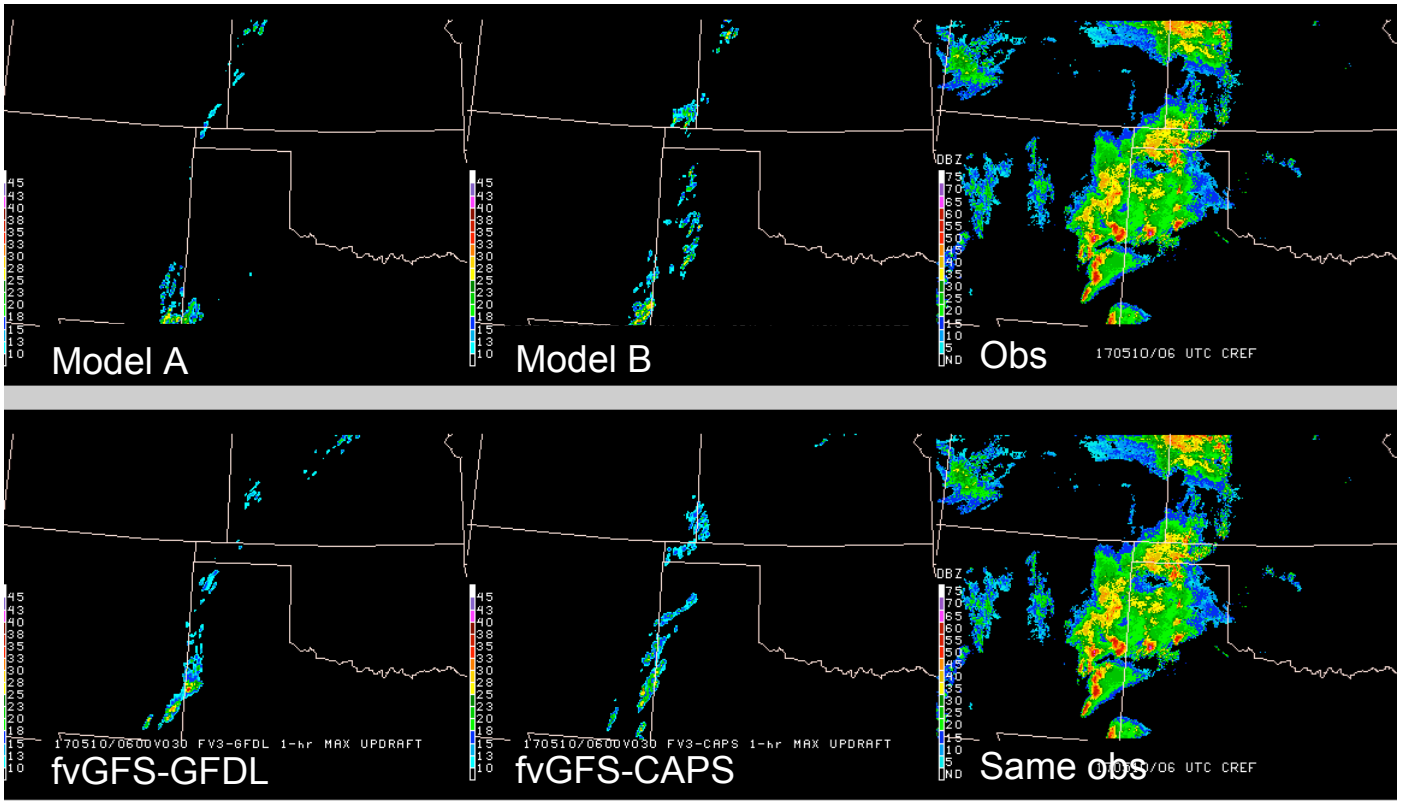
Hourly-max 2–5 km Updraft Helicity

+30 hr, init 00z

0510

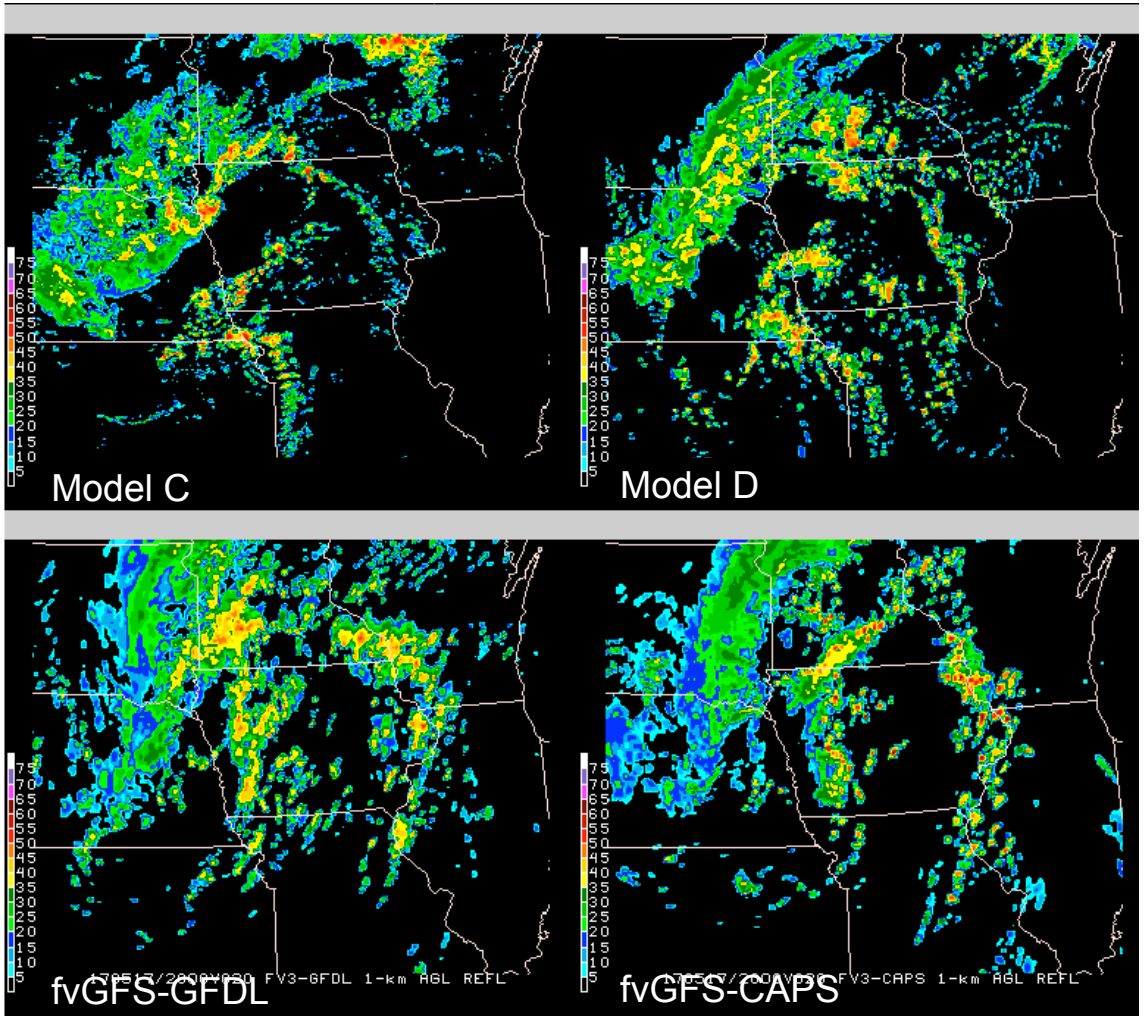


Hourly- and column-maximum updraft +30 hr, init 00z 0510



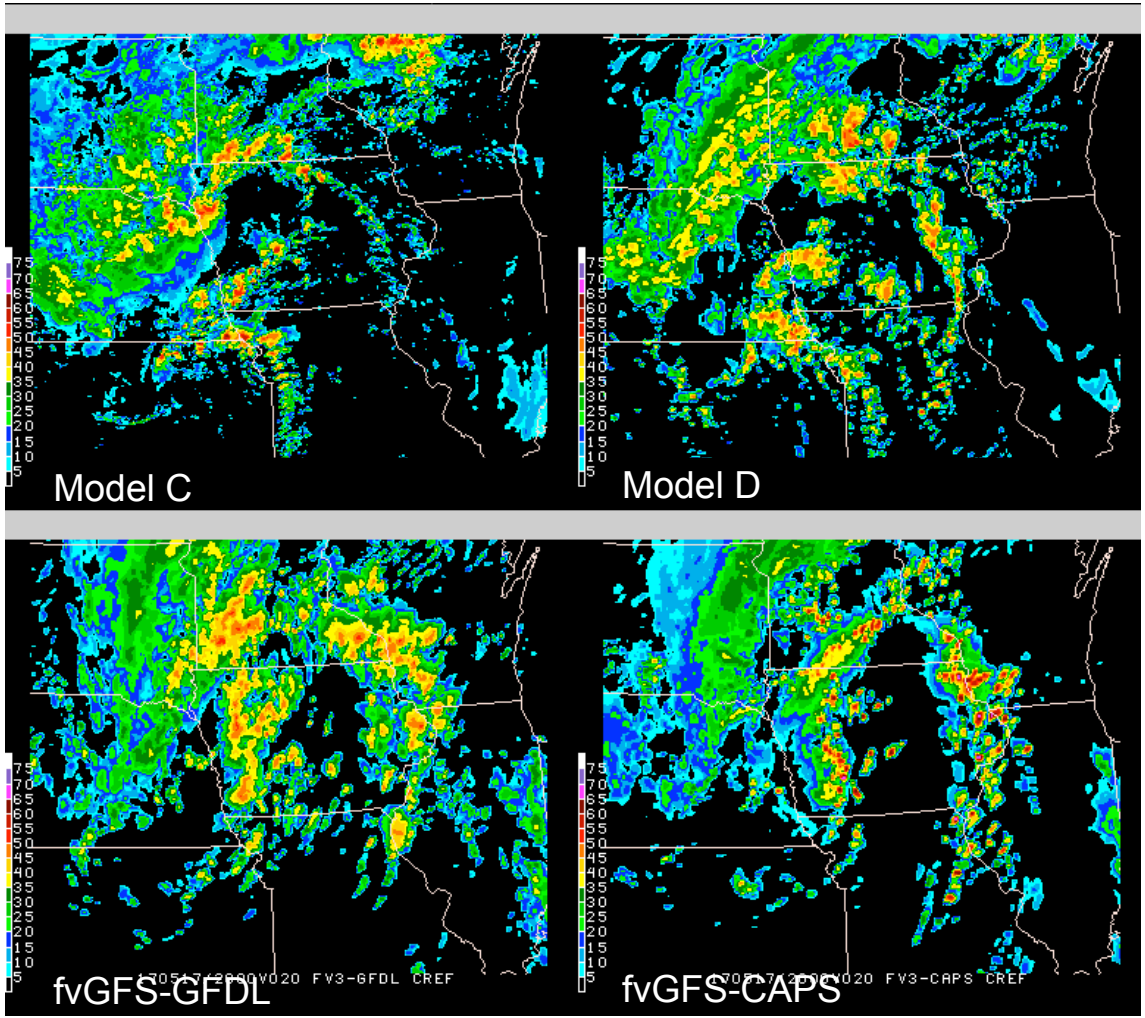
Base Reflectivity

+20 hr init 00z 0517



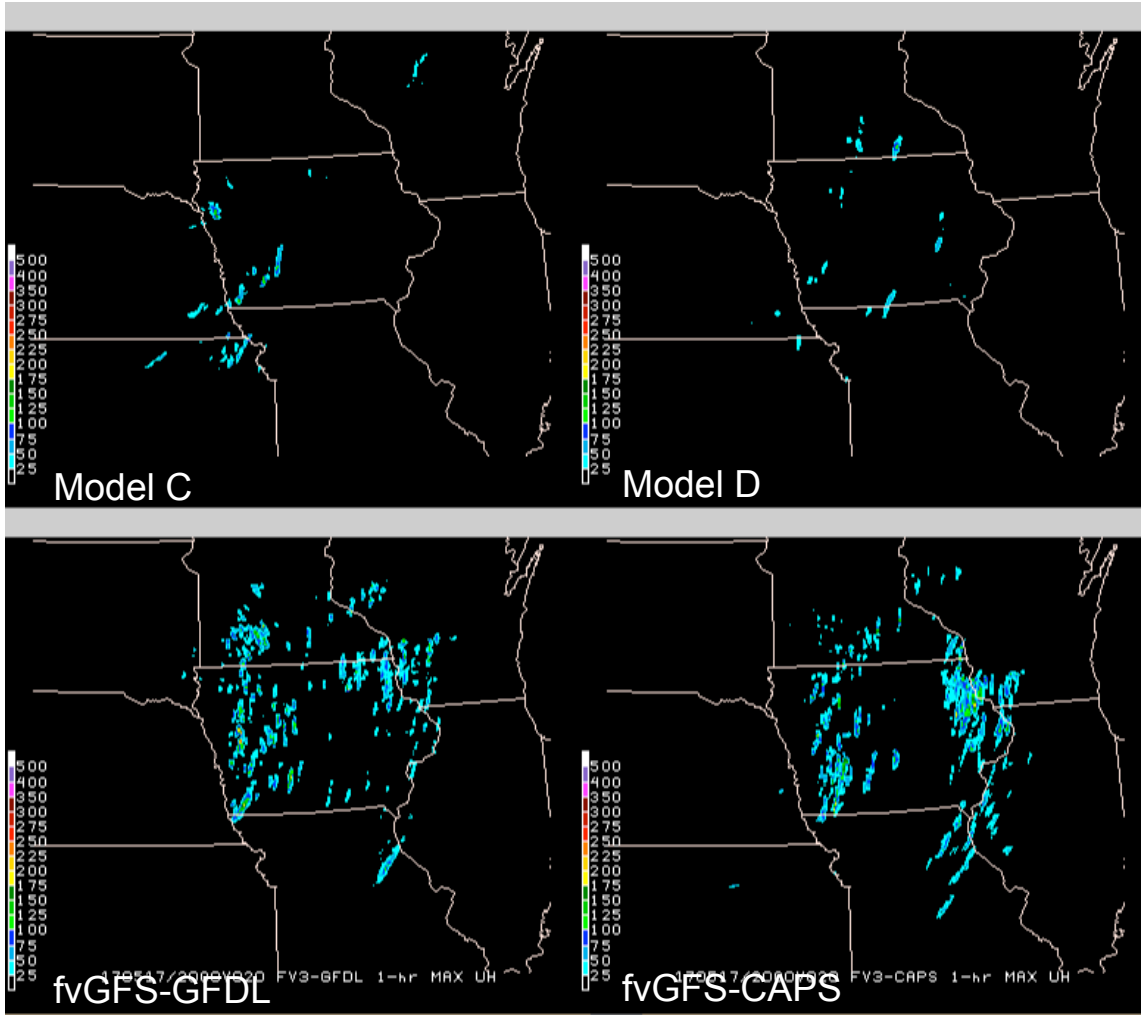
Composite Reflectivity

+20 hr init 00z 0517



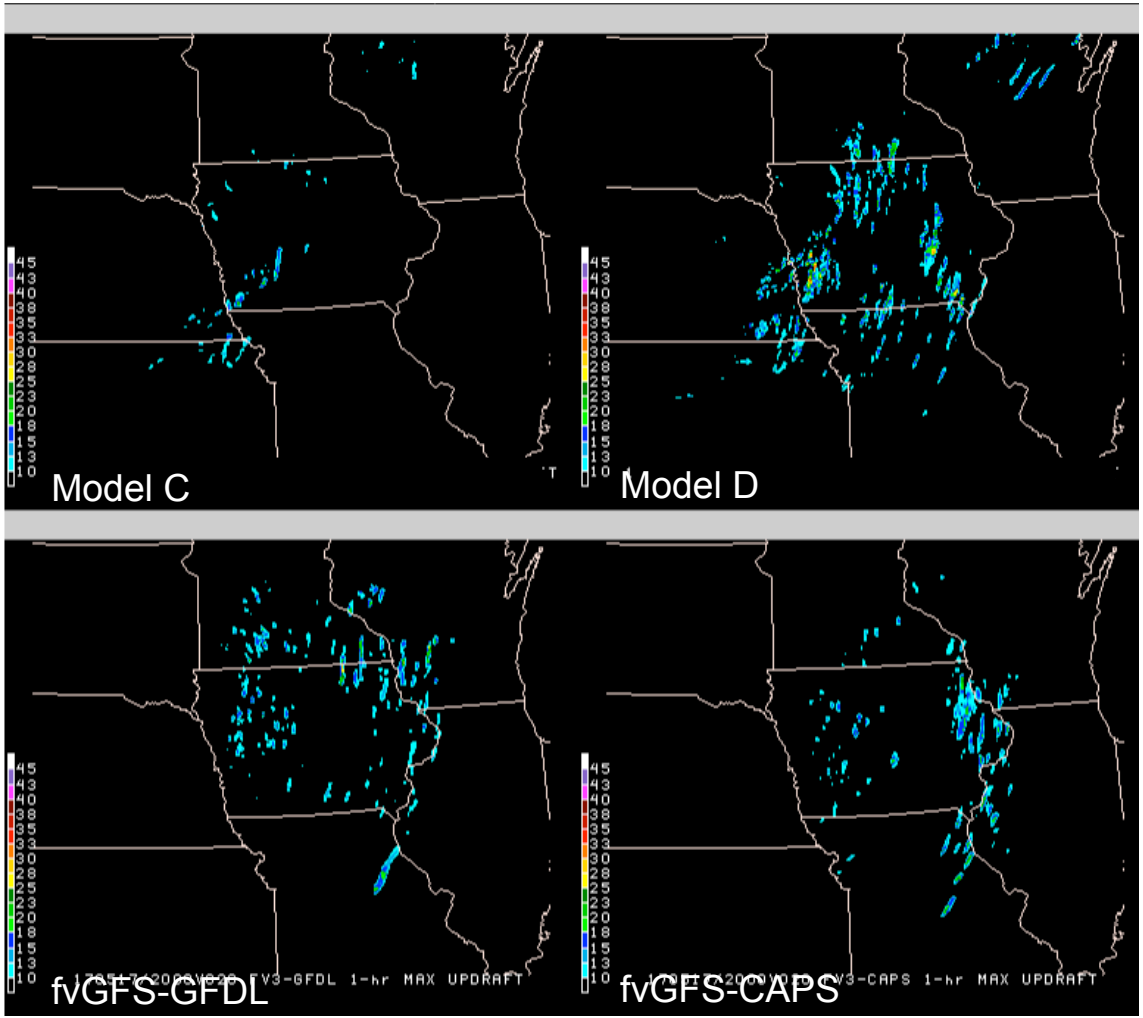
Hour-max 2–5 km UH

+20 hr init 00z 0517



Hour- and column-max updraft

+20 hr init 00z 0517



Towards a global-to-regional CAM

Building on critical NOAA partners and community collaborations with
EMC, OU/CAPS, AOML, NASA, and Penn State

Thompson microphysics in fvGFS-CAPS looks much better in intensity!
GFDL microphysics reasonable but intensities need improving—
need modifications to hydrometeor fall scheme?

Better PBL scheme a **must**; the GFS PBL is suboptimal for CONUS.
CAPS is implementing YSU PBL.

Initialization: Radar & satellite DA work proposed by OU and Penn State for 2018
for HWT/Hurricane

FV3GFS is a drastically new regional-global modeling system, which may require

Naive proposal for rapidly-updating multiple-cadence unified DA

All runs are unified two-way global-to-regional with at least one (CONUS) nest—both global and regional models stand to benefit

:00—:05: Assimilate US radar (and satellite) in fvGFS once available
Begin nowcast-timescale global-to-CONUS-to-WoF run(s)

:05–:15: Assimilate global satellite and surface obs data once available
Begin SREF/HREF-length global-to-CONUS runs

:15–:00: Assimilate remaining slow global surface and radiosonde data
Begin medium-range/extended-range run

Summary

"Suitability" of FV^3 for convective-scale forecasts has been demonstrated.

Global-to-regional 2-way nesting maintains global skill while providing regional details

Current FV^3-based CRM is still primitive. Much much more work needs to be done, especially on the **physics** (cloud MP and PBL) and **DA** -- **these are areas where the community can make great contributions!**

As demonstrated by 2017 HWT, fvGFS can mimic a regional model with a refined global grid. This removes the need for BCs and is more efficient than some operational regional models

Unified model approach: systematic year-round evaluation will be crucial. Cannot tune for just one season for only one type of events. Must also consider TCs,