The Hazardous Weather Testbed

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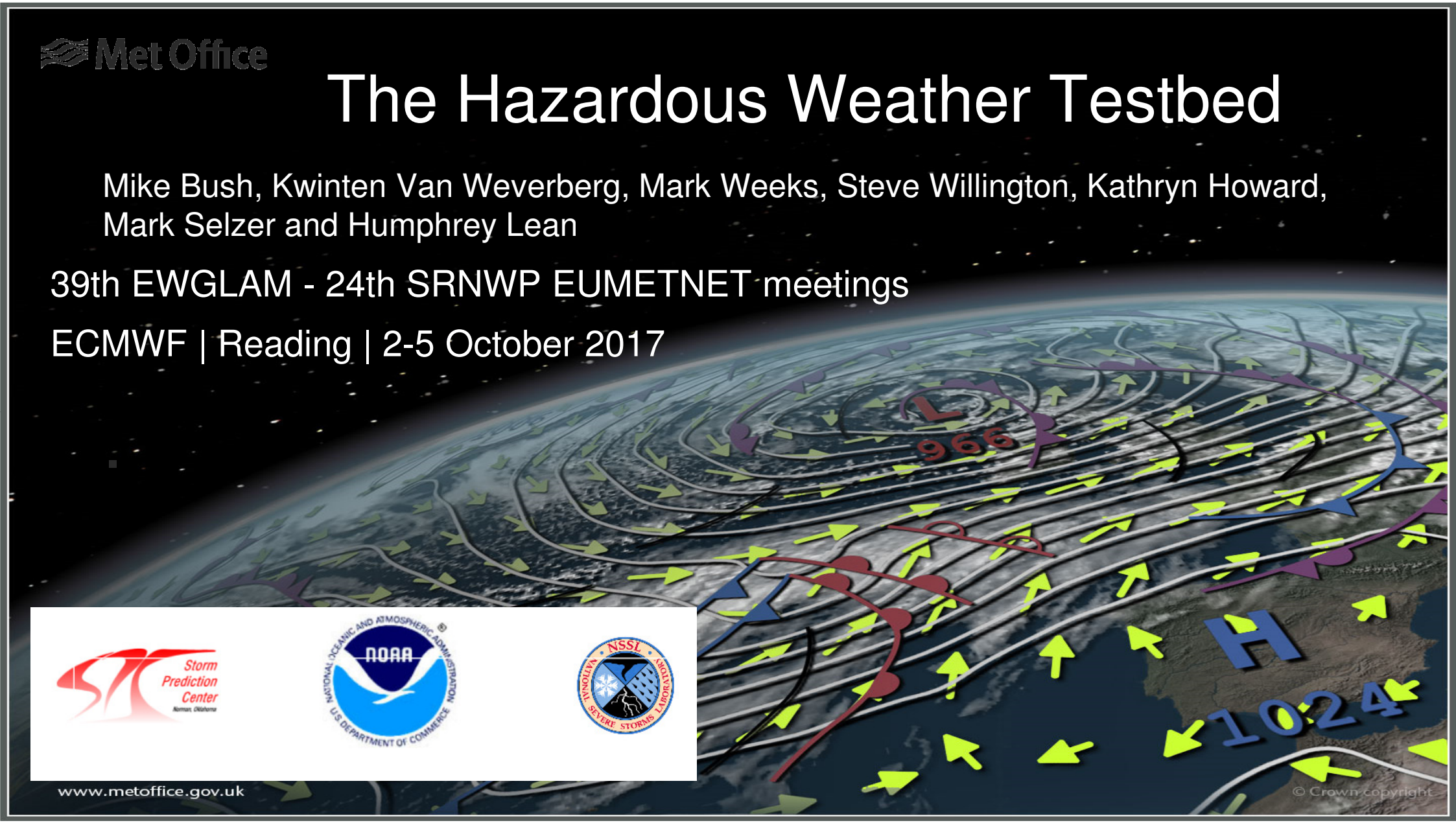
39th EWGLAM - 24th SRNWP EUMETNET meetings

ECMWF | Reading | 2-5 October 2017



Storm Prediction Center

NOAA

NSSL

www.metoffice.gov.uk

National Weather Center, Norman, Oklahoma

National Weather Center, Norman, Oklahoma

- The National Weather Center building houses many organizations
- National Oceanic and Atmospheric Administration (NOAA) National Severe Storms Laboratory (NSSL)
- The Storm Prediction Center (SPC), a government agency that is part of the National Centers for Environmental Prediction (NCEP), operating under the control of the National Weather Service (NWS) which in turn is part of the NOAA
- University of Oklahoma (OU) School of Meteorology

NSSL and SPC

- The National Severe Storms Laboratory (NSSL) is one of seven NOAA weather research laboratories

- NSSL studies weather radar, tornadoes, flash floods, lightning, damaging winds, hail, and winter weather in an effort to improve warnings and forecasts.

- Researchers at NSSL developed the first Doppler weather radar, and have contributed to the development of NEXRAD (WSR-88D).

- The group conducts various research experiments using mobile radar systems.

- The Storm Prediction Center is tasked with forecasting the risk of severe thunderstorms and tornadoes in the contiguous United States.

- It issues convective outlooks out to Day 8 and also mesoscale discussions, and watches as a part of this process.

- It also issues the risk of severe thunderstorms, tornadoes, hail and wind events out to Day 3.

The Hazardous Weather Testbed (HWT)

- The HWT is organised by NSSL and NWS.

- Each Spring severe weather season, ±80 researchers and forecasters gather at NSSL for 5 weeks to evaluate emerging scientific concepts and tools in a simulated forecasting environment.

- Focus this year on probabilistic forecasts on short time periods, using large WRF ensemble (81 members - CLUE), 3 flavours of UM and operational SPC, EMC and NSSL ensembles.

- Gallo et al (2017) http://journals.ametsoc.org/doi/full/10.1175/WAF-D-16-0178.1

Timeline of Met Office HWT Models

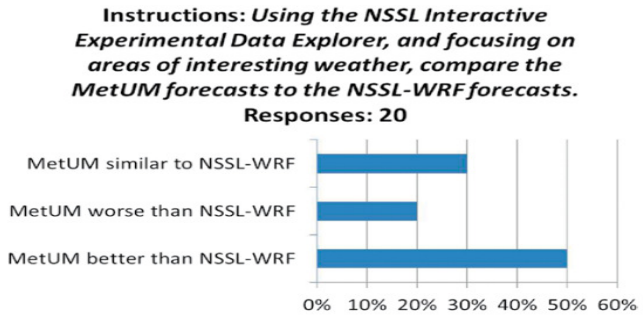
	Main models	Trial models
2013	4.4km and 2.2km downscalers UKV operational config (PS32)	3d smag mixing
2014	4.4km and 2.2km downscalers UKV operational config (PS34) but including ENDGAME dynamics nested in ENDGAME global model	Blended BL scheme
2015	2.2km and 1.1km downscalers UKV operational config (PS35)	PC2 cloud scheme
2016	2.2km and 1.1km downscalers UKV operational config (PS37)	Moisture Conservation
2017	2.2km downscaler. Forecast out to T+120 UKV operational config (PS39).	Proto RA1-M, RA1-T

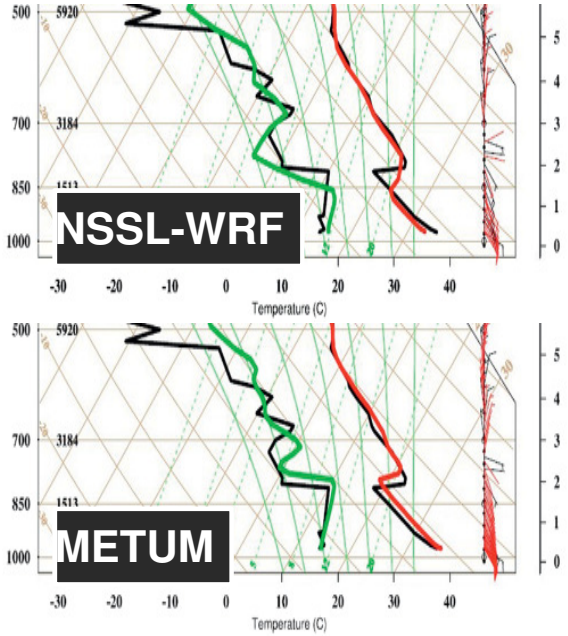
Models set-up and implemented by Mark Weeks

Outcomes from previous years

Humphrey Lean

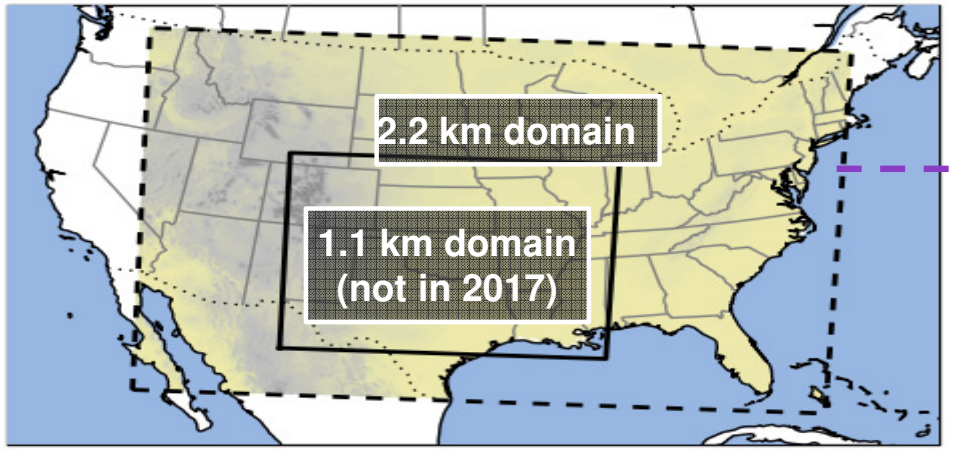
- Generally UM models performed well compared to NSSL-WRF (subjective verification).
- Encouraging performances for several high profile cases.
- Convective initiation generally good although often not initiating or not widespread enough.
- Models good at developing supercellular features and upscaling to larger convective complexes etc.
- Poor at growing and organising mid level convection.
- UM better than WRF at generating inversions in profiles.
- http://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-15-00199.1

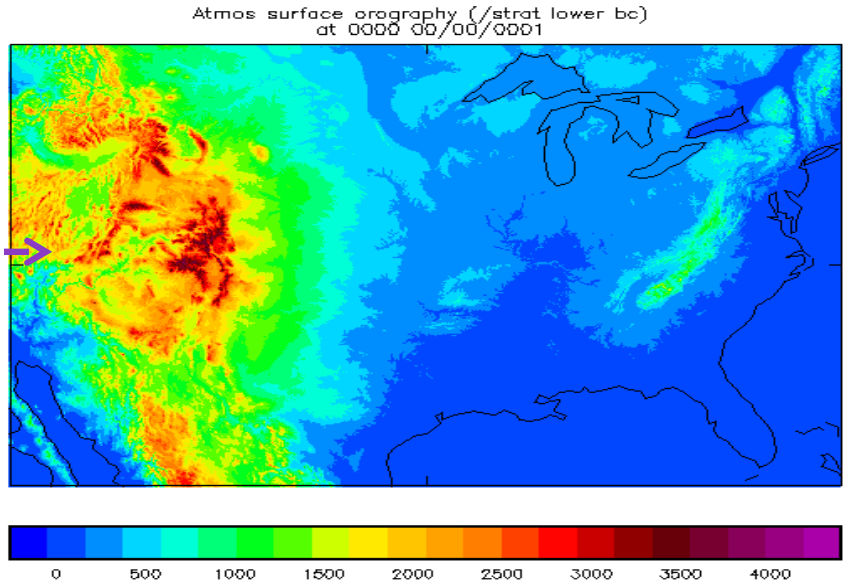




BAMS paper 2017: Kain et al.

UM Model configuration: US 2.2 km





- Grid = 1700 x 1200
- 2 million gridpoints
- 32 nodes: 60 mins

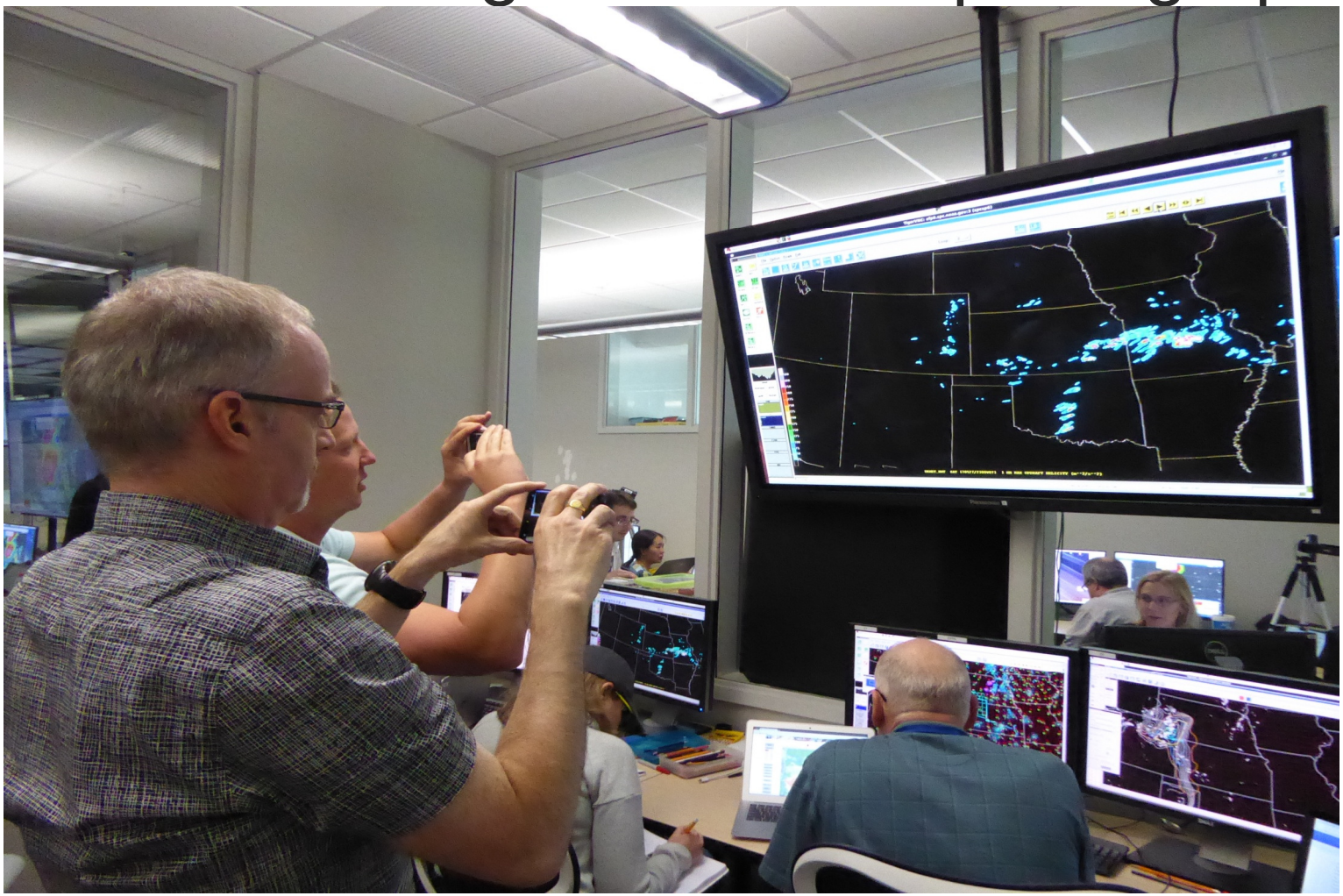
- Nested in the Global Model, includes most of CONUS except W coast.
- Downscaler; starts from 0Z analysis, hourly LBCs, runs to T+120
- Operational run as UKV science (PS39)
- Two parallel runs (proto RA1-T: tropical and RA1-M: mid-latitude)

Updraft helicity diagnostic coded into UM

- Updraft helicity as a forecast diagnostic has shown a particular ability to identify supercell-like structure in convection.
- Kain et al. (2008) paper in Weather and Forecasting
- http://journals.ametsoc.org/doi/full/10.1175/WAF2007106.1
- $$\mathrm{UH} = \int_{z0}^{z_t} w\zeta \, dz, \qquad (11)$$
- where ζ is the vertical component of the relative vorticity
- Relative Vorticity * vertical velocity * layer thickness integrated over levels in the range 2-5km.
- Focus is on cyclonically rotating updrafts where both w and ζ are positive in NH. If the vertical velocity on a level is downward (-ve) that contribution is set to zero.

- Max values over a short time window may be more useful than instantaneous values.

A Model diagnostic worth photographing?



The challenge of forecasting

- Each morning we would hand draw analysis charts on various levels and familiarise ourselves with the environmental conditions and areas that were conducive to development. Where is the best shear? CAPE? Moisture? Overlap?

- We would then be under time pressure to look at a range of model output and come up with warning areas for tornadoes, hail and wind for different forecast periods by a certain deadline.

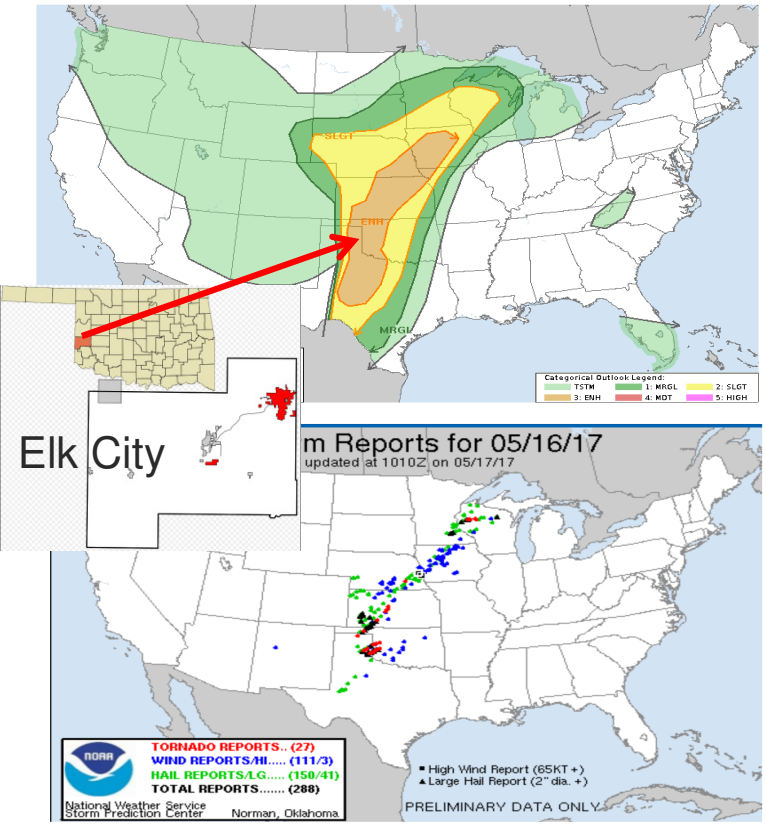
- The focus this year was on higher temporal resolution for warnings, so we had to issue maps for the individual hazards that had a 4 hour validity time and draw isochrones (lines showing position of severe weather at the same time) each hour.

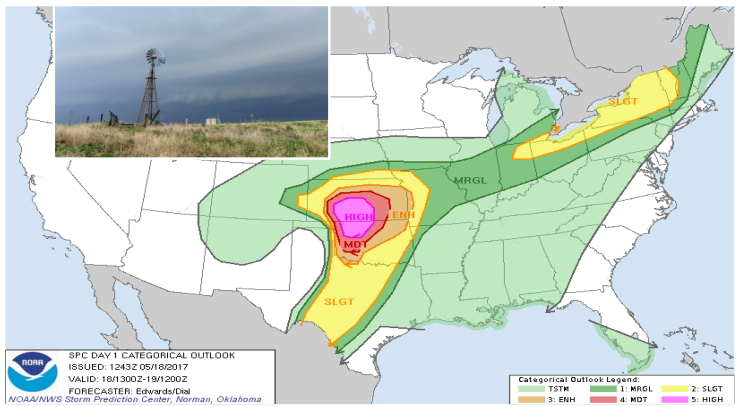
- It was tempting to make these areas fit too closely to the (ensemble) model output only to find the next day that some of the actual hazards popped up outside the warning areas.

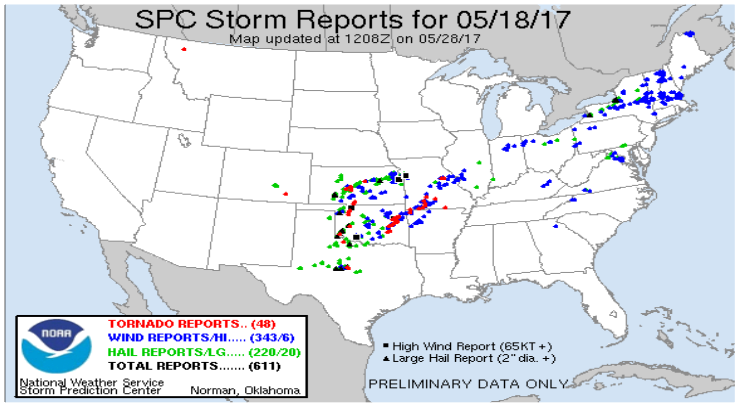
- However, areas are huge (Oklahoma is larger than England and Wales) so having the warning areas too large is also not helpful...

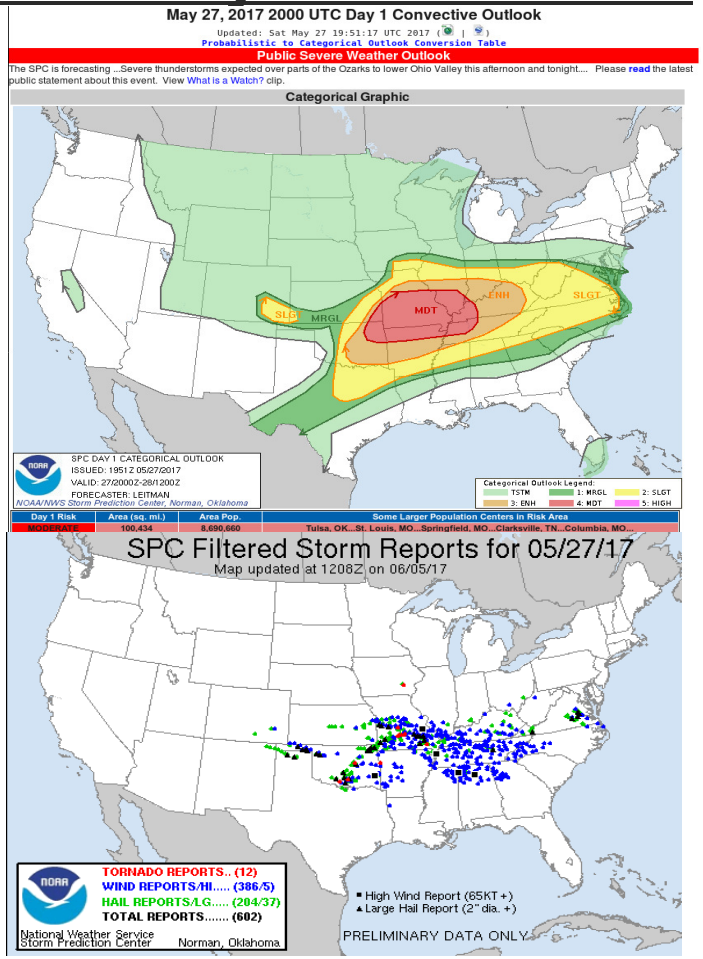
Three case studies from HWT 2017

16 May: Supercells 18 May: squall line 27 May: Tornadoes





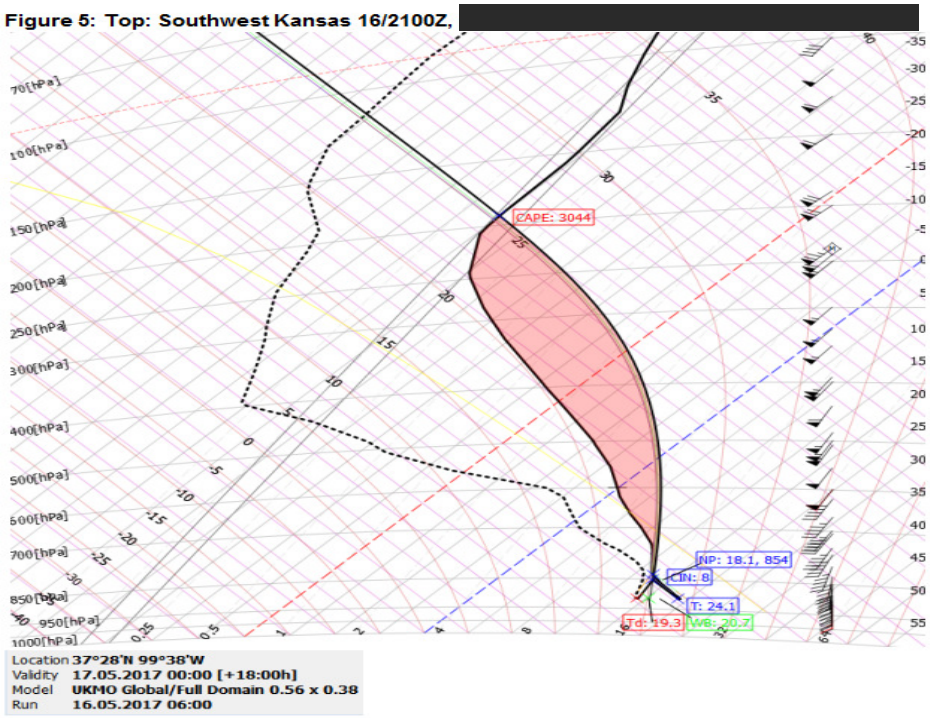





ELK CITY, OK SUPERCELL
& RAIN-WRAPPED TORNADO
MAY 16, 2017

16 May 2017: Supercells

Environment

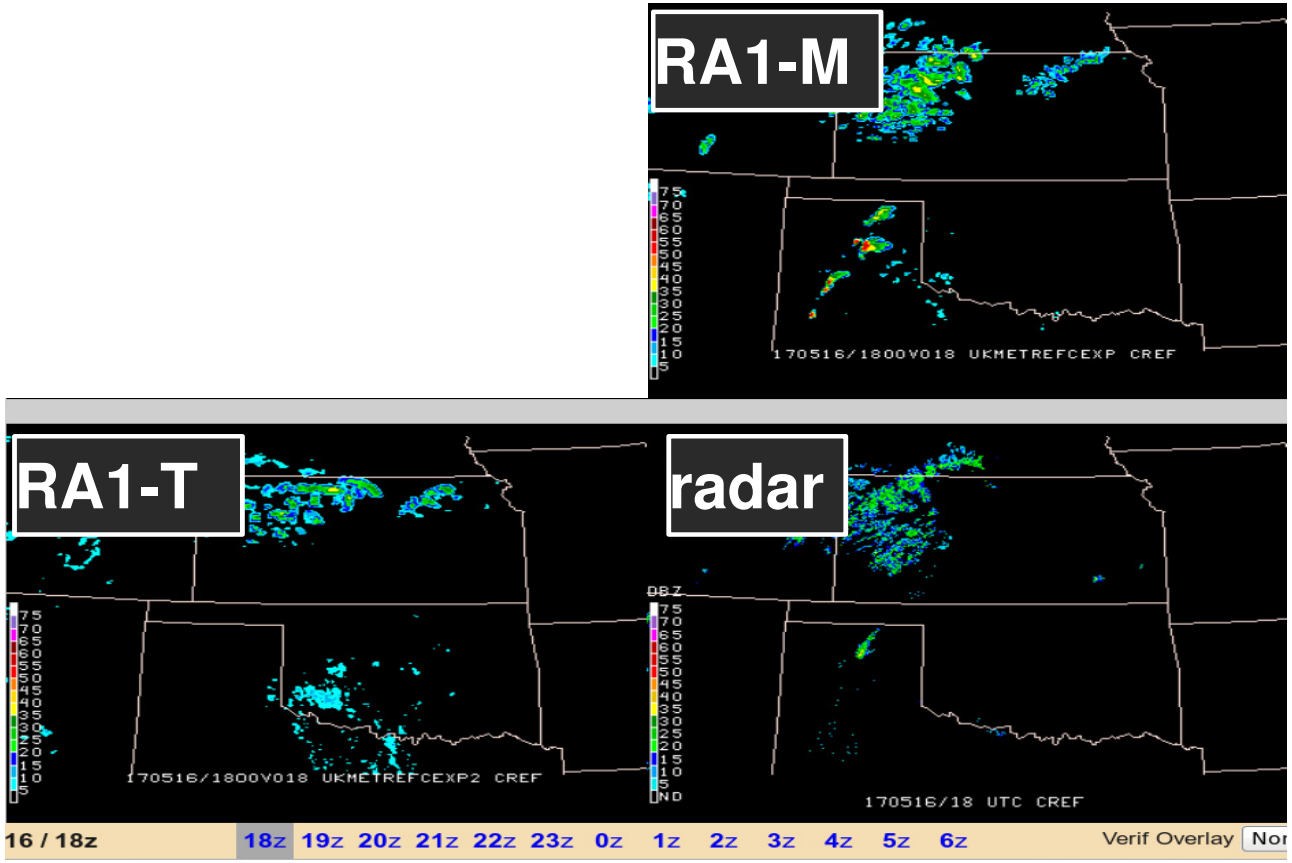


- Reasonable low/mid level shear
- Fair depth of moisture
- Lot of CAPE (3000-3500)
- Dry air aloft (lightning)
- Low bases in moist air (condensation funnels)
- High precip and giant hail plausible.
- Increasing CAPE with height (vortex stretching and enhanced long-lived tornado risk)

Mark Selzer

16 May 2017: US2 performance

Initiation and structure



16 May 2017: US2 performance

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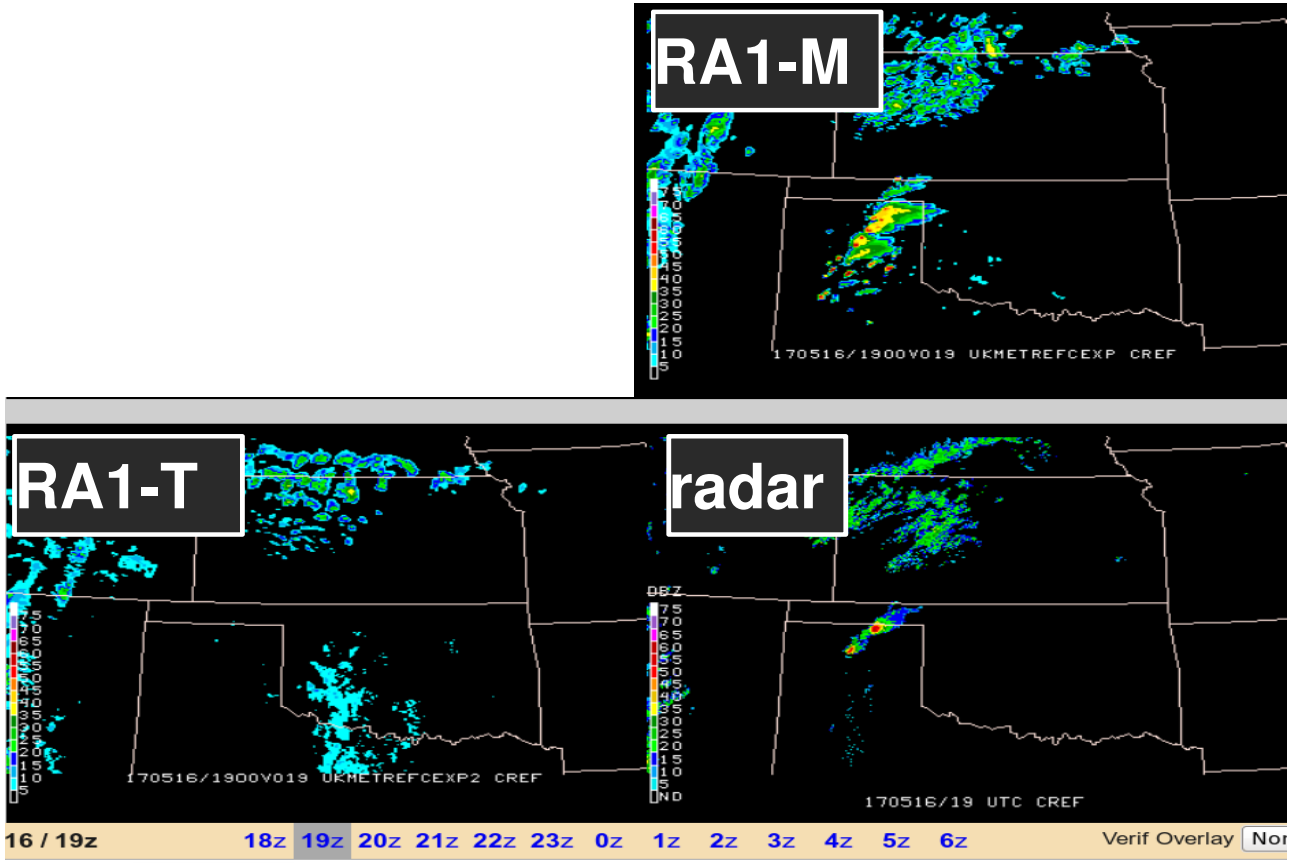

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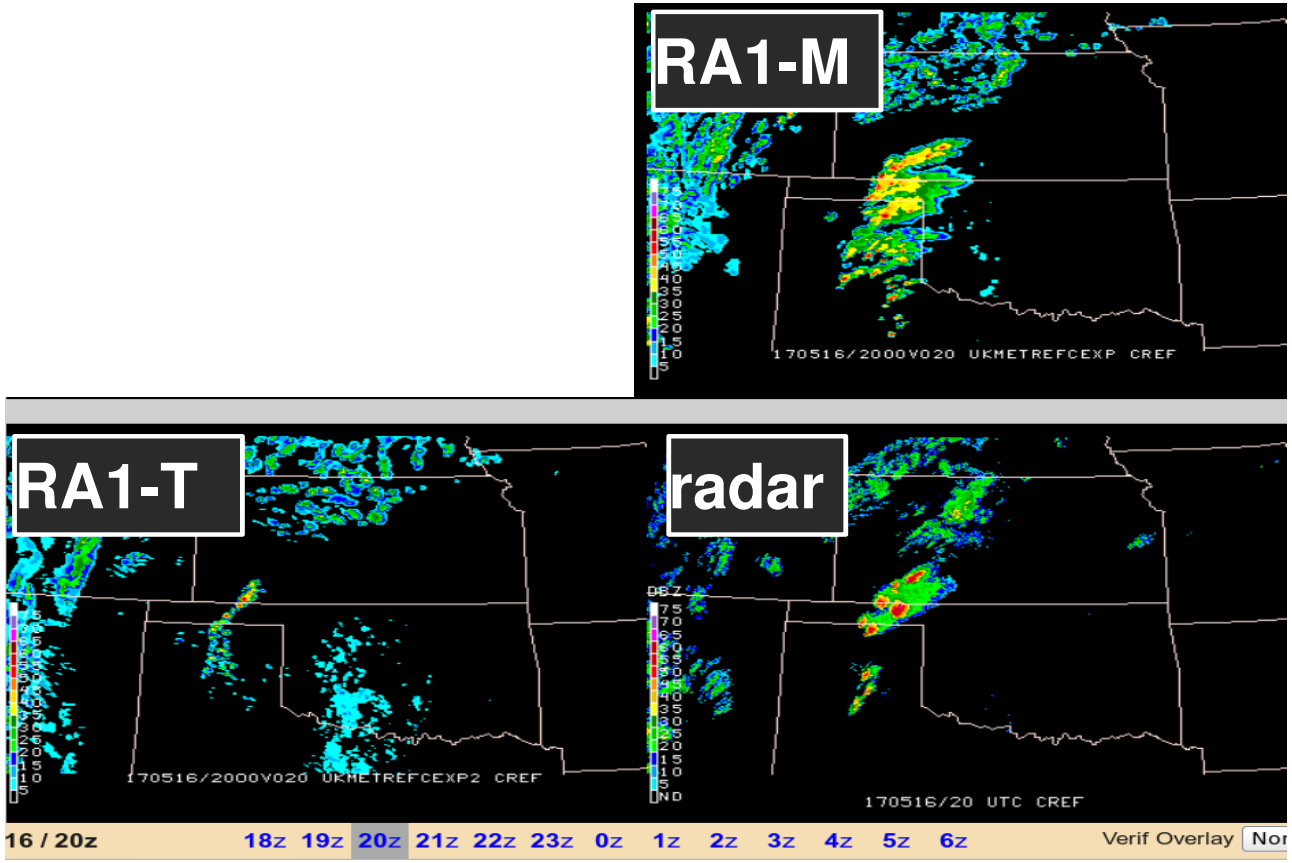
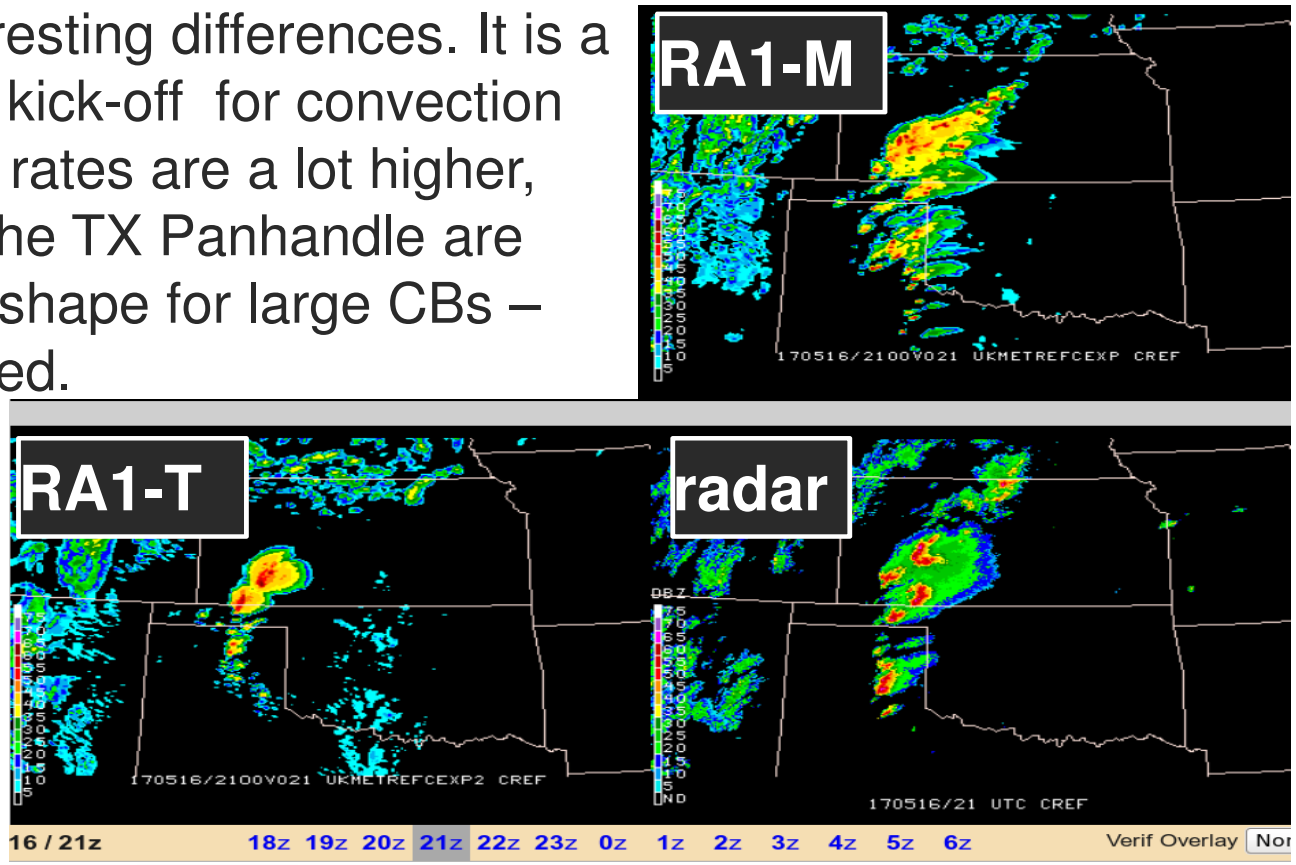


16 May 2017: US2 performance

Initiation and structure

The RA1T has some interesting differences. It is a couple of hours slower at kick-off for convection over the panhandle. Rain rates are a lot higher, and the cells fired out of the TX Panhandle are possibly of more realistic shape for large CBs – blobby rather than speckled.



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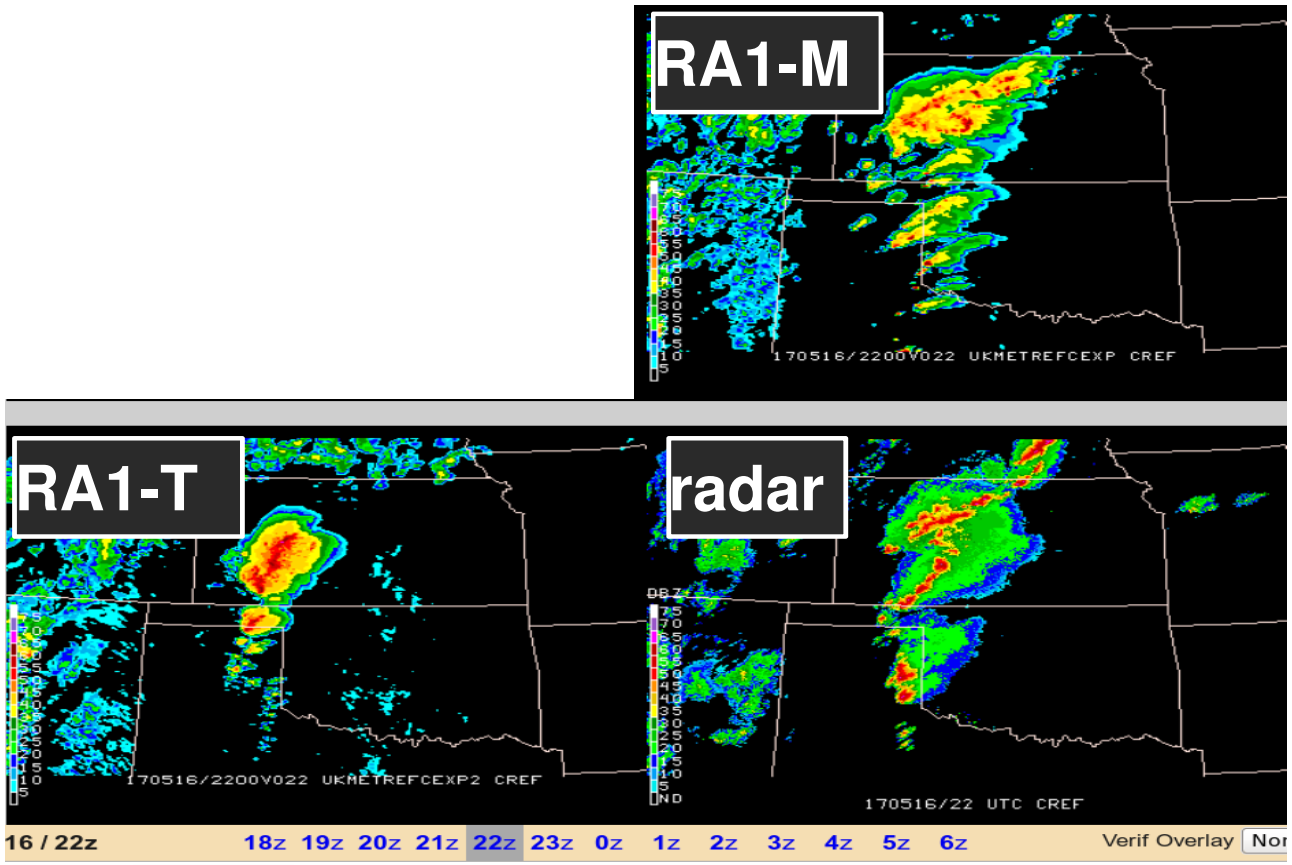
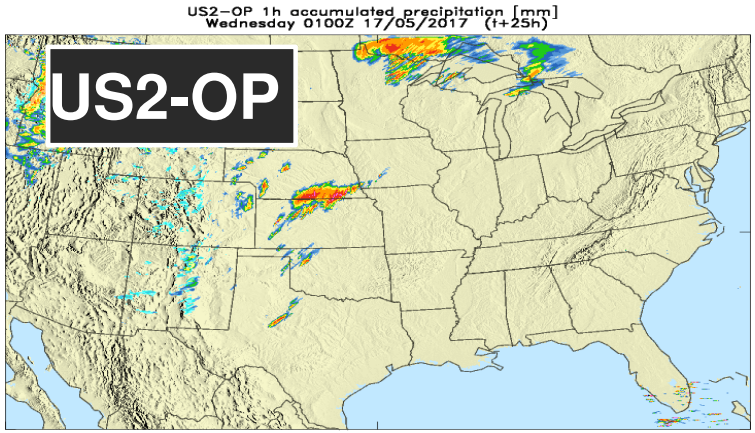
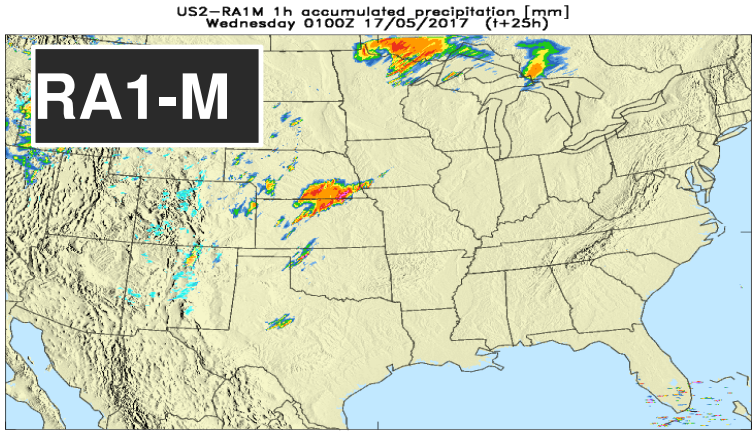
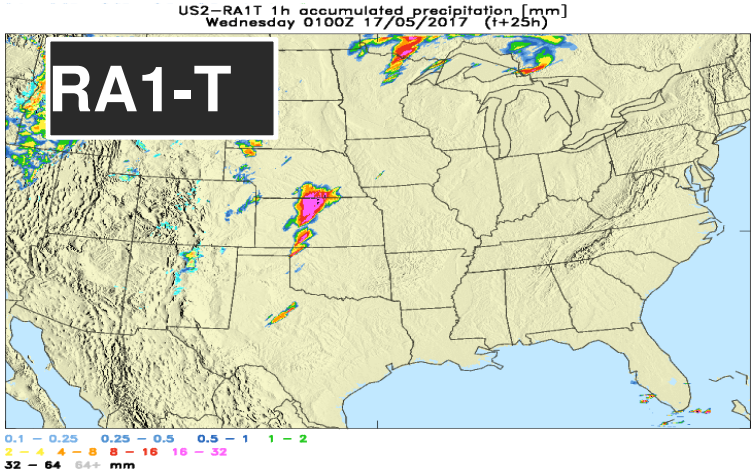


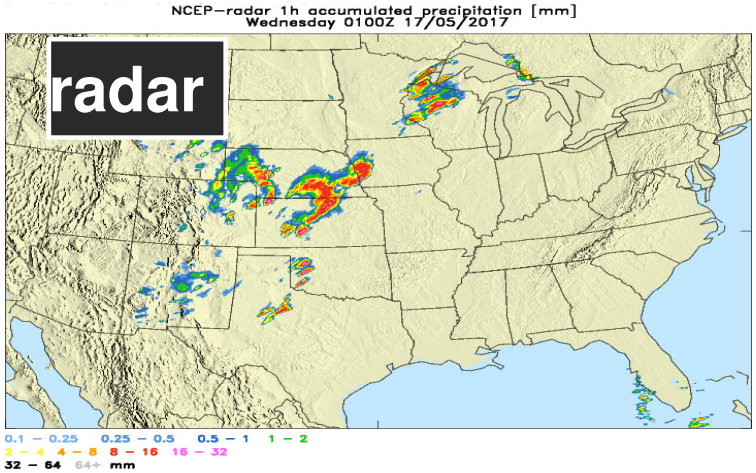
16 May 2017: US2 performance

Precipitation rates



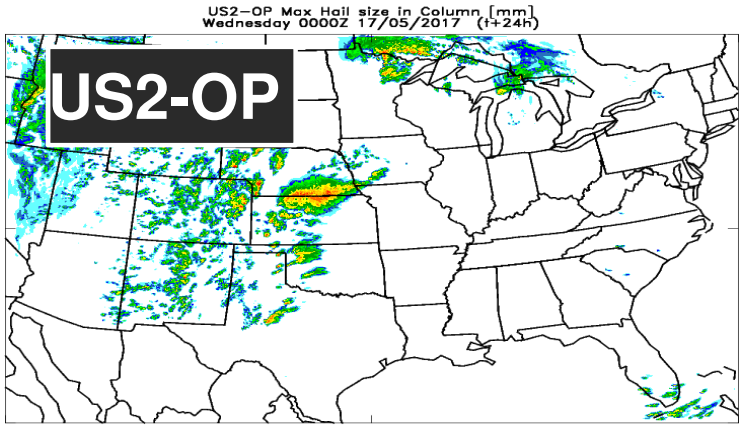


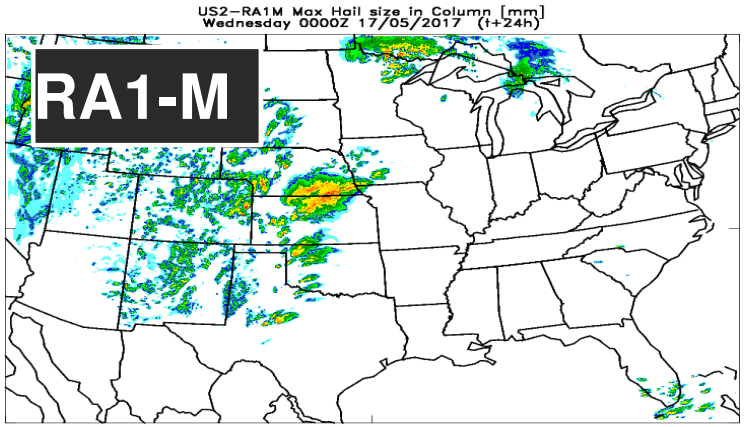


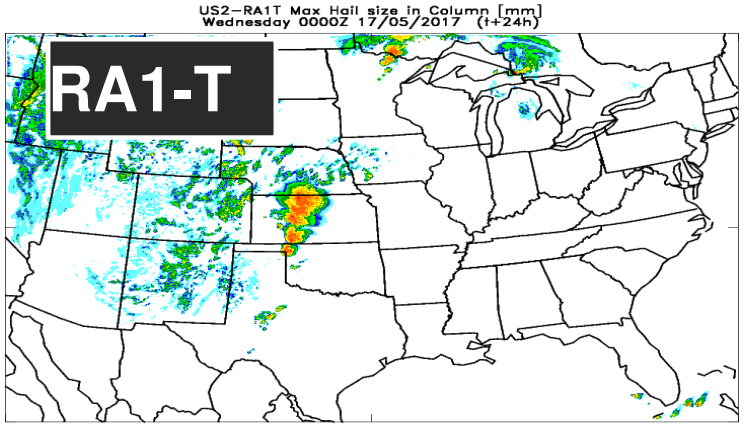


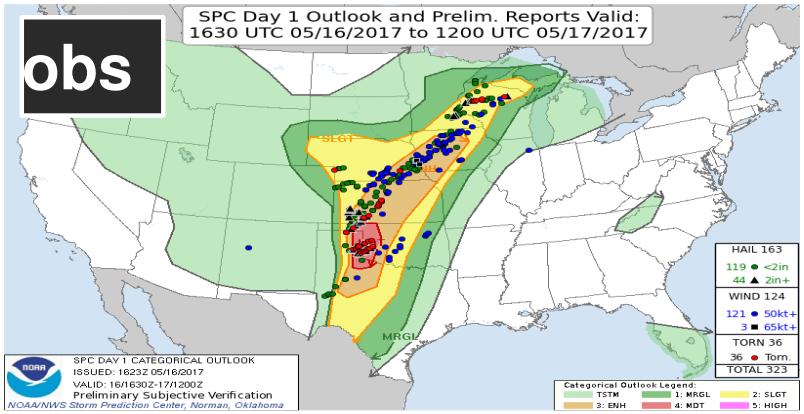
16 May 2017: US2 performance

Hail Size Diagnostic (using graupel PSD in microphysics)

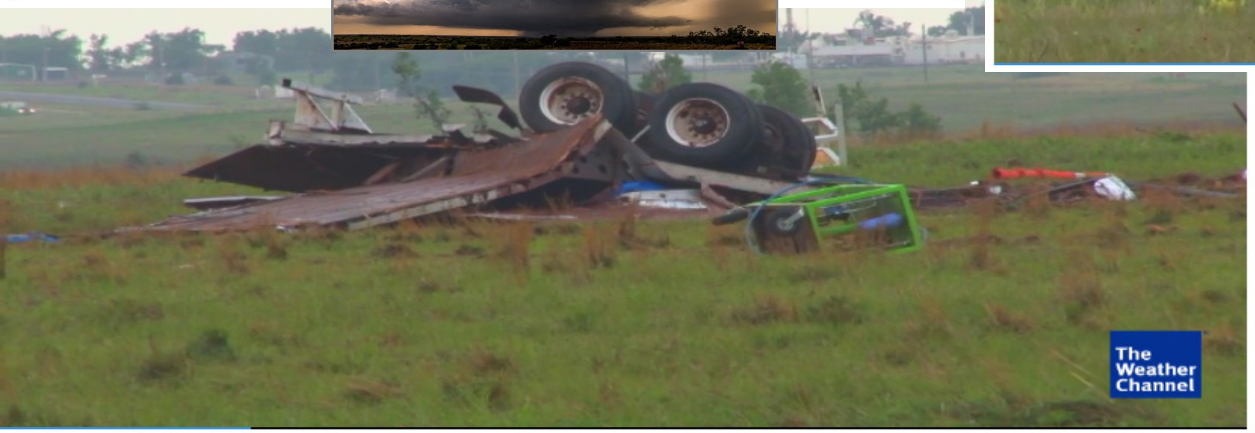






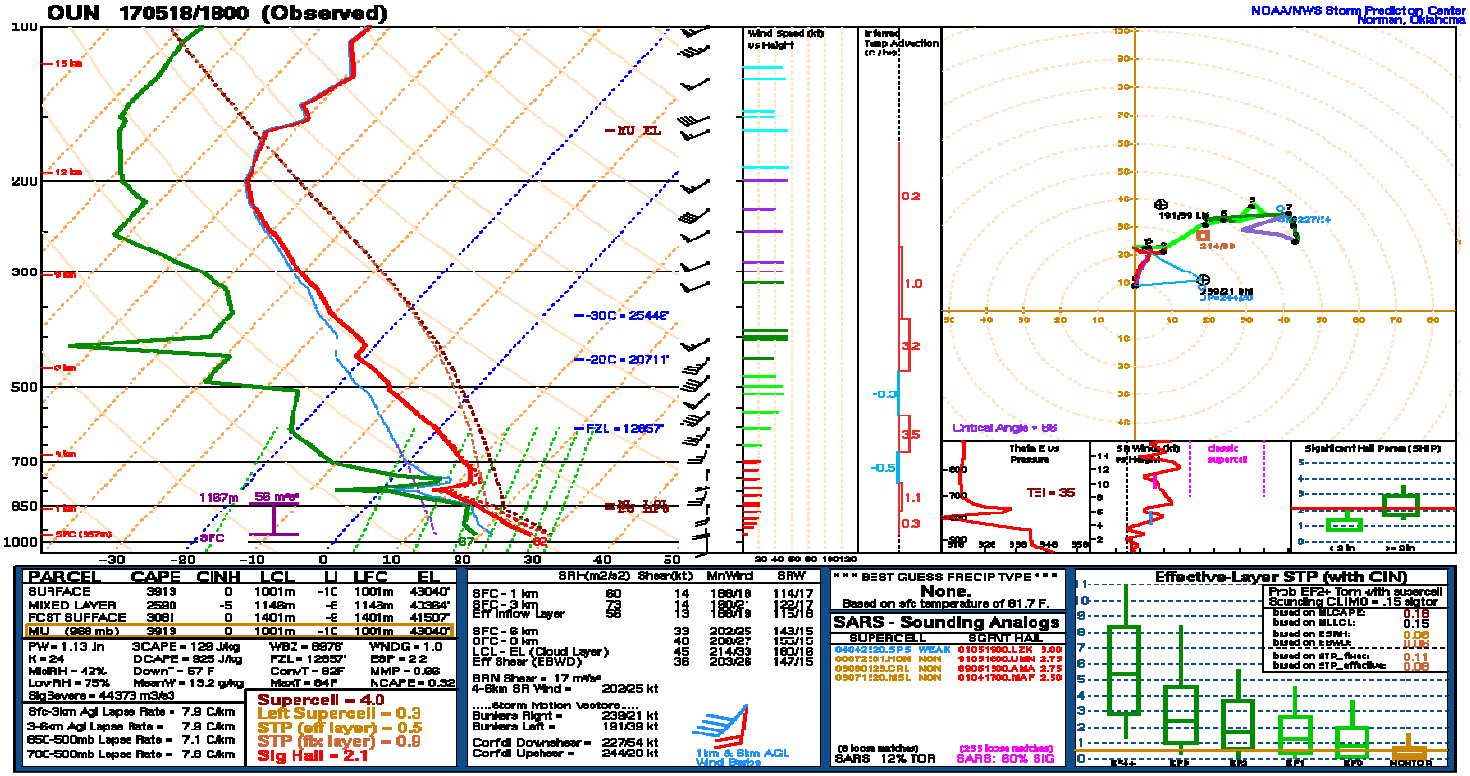


Elk City, Oklahoma 16th May



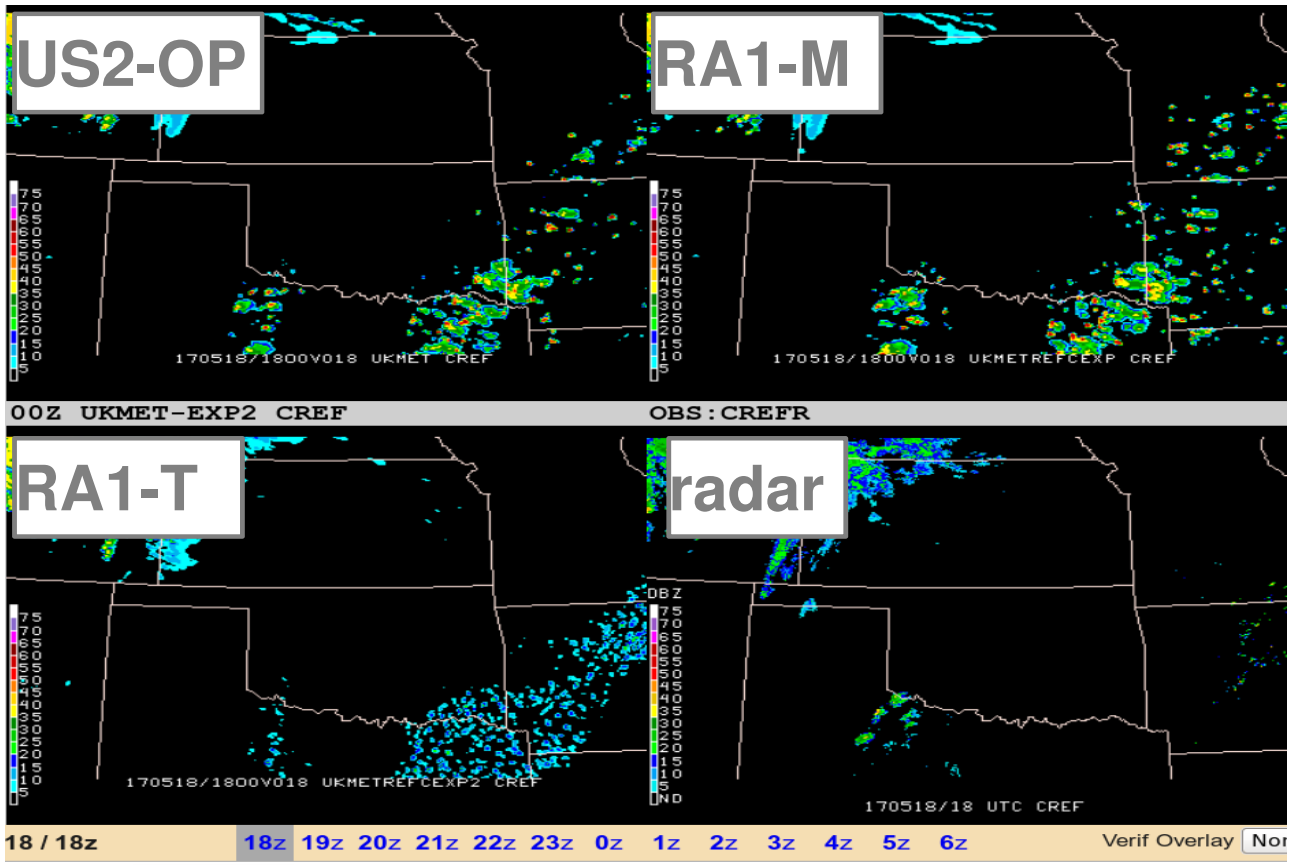
18 May 2017: Squall line

Environment



18 May 2017: US2 performance

Initiation and structure



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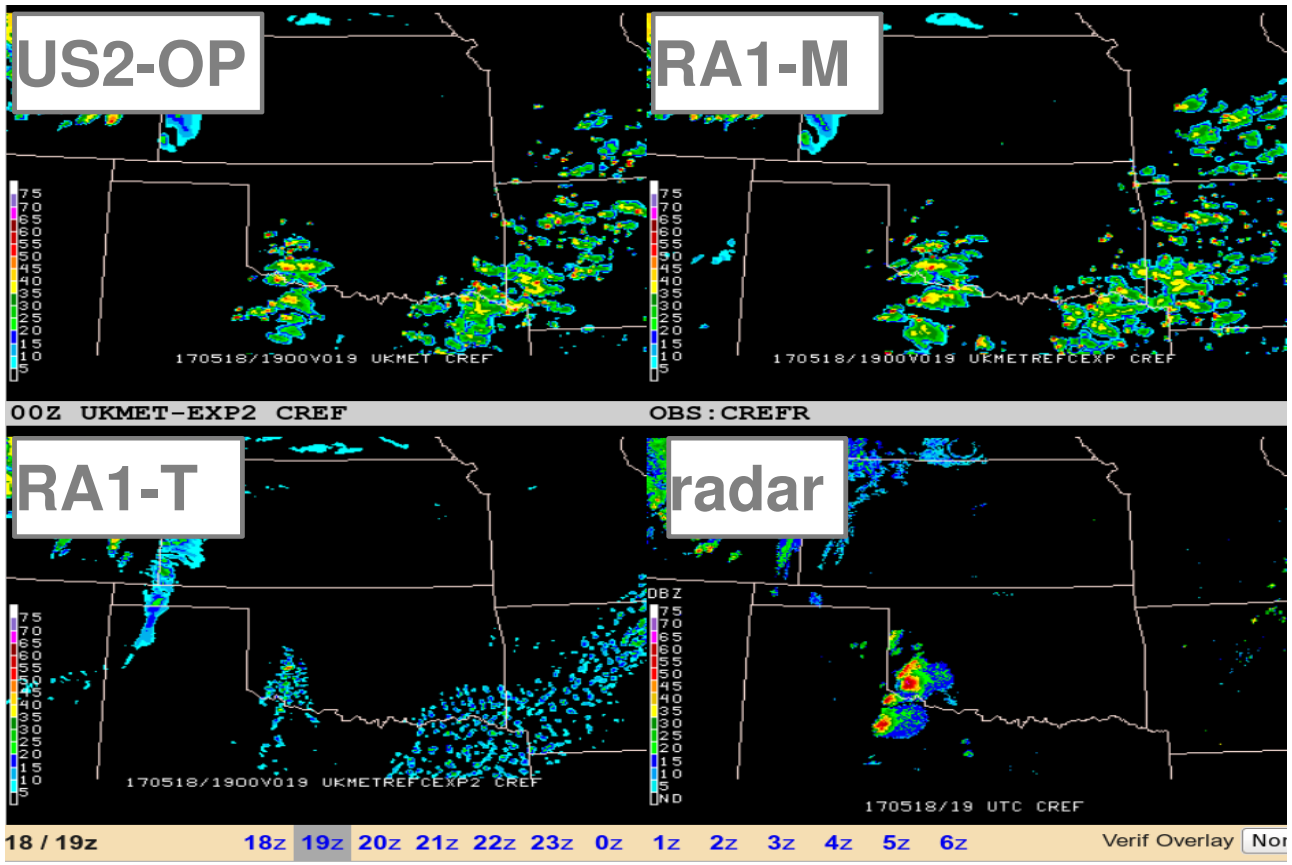

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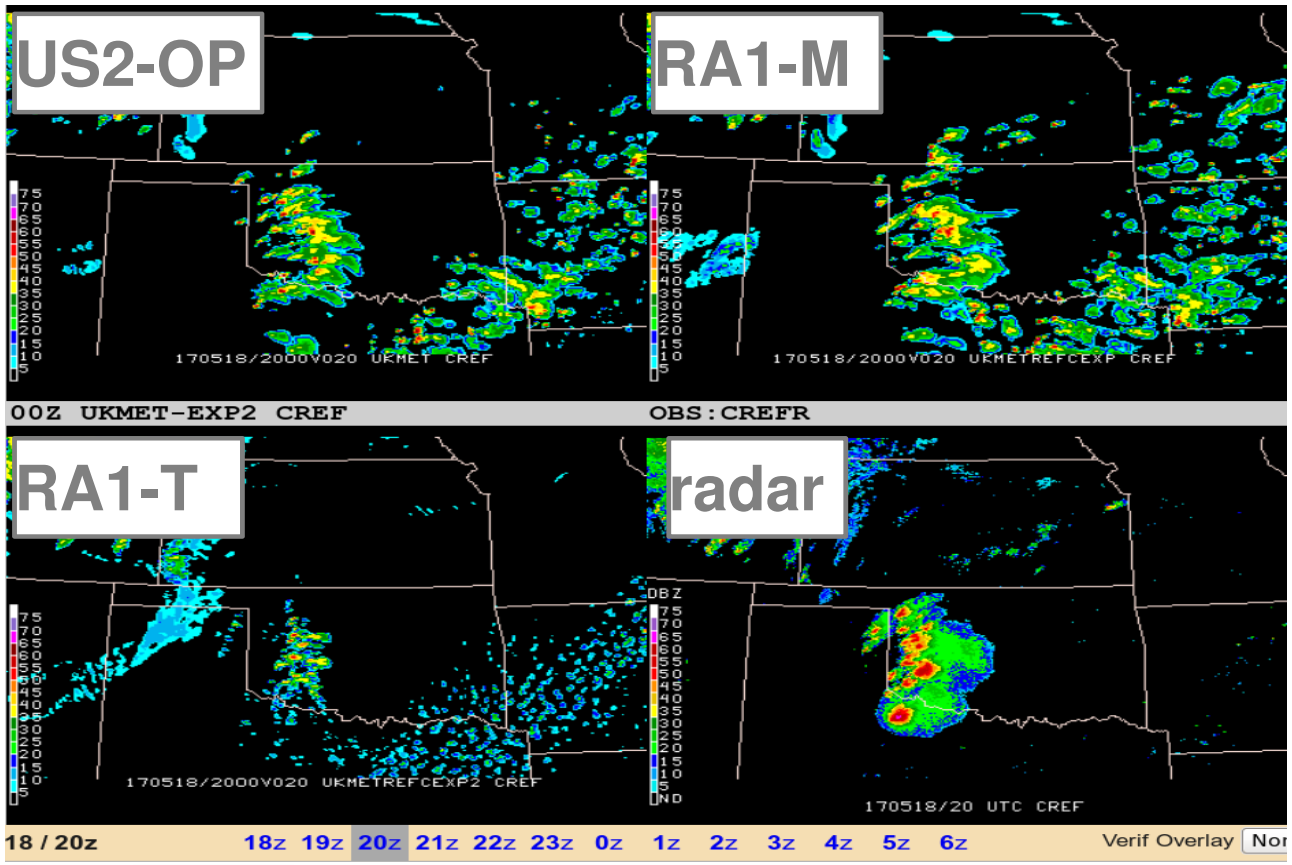

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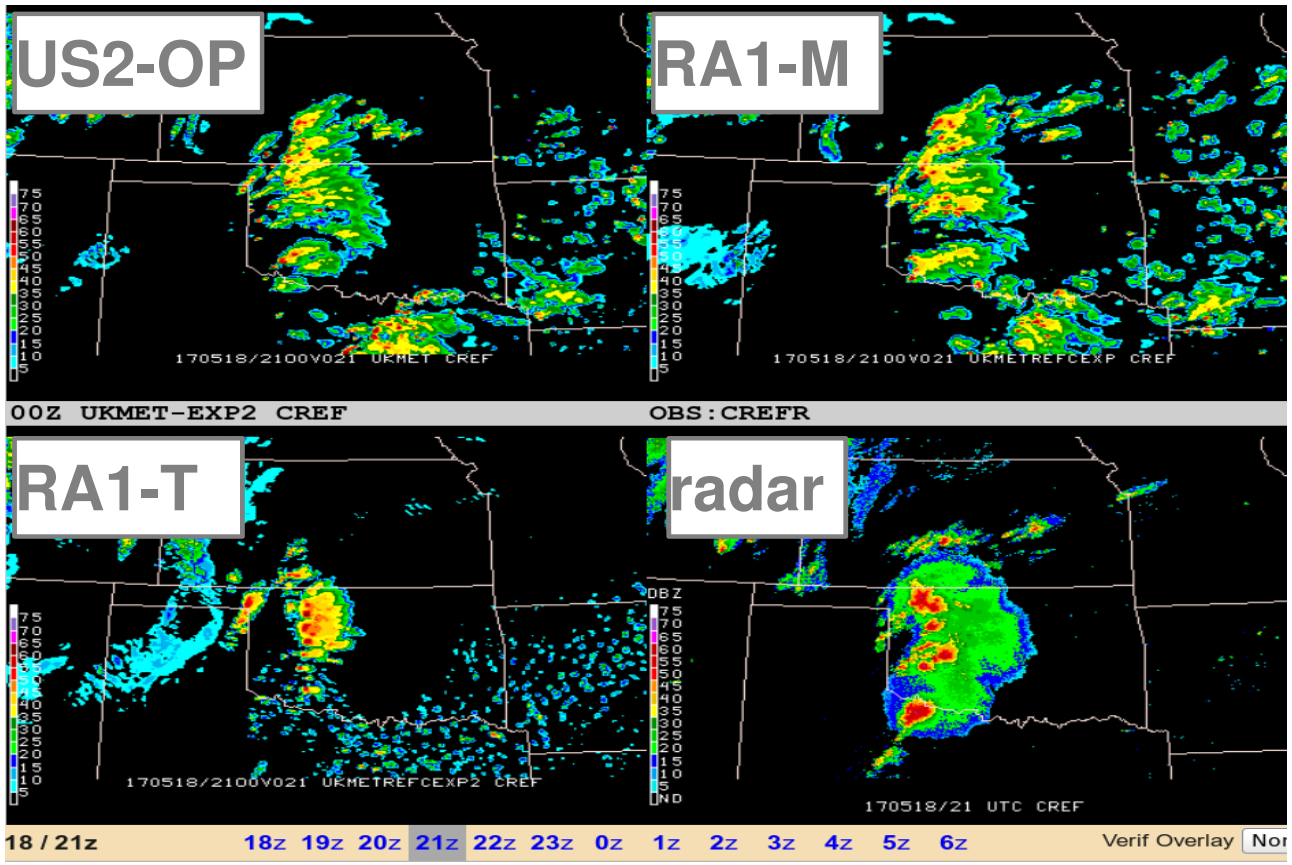

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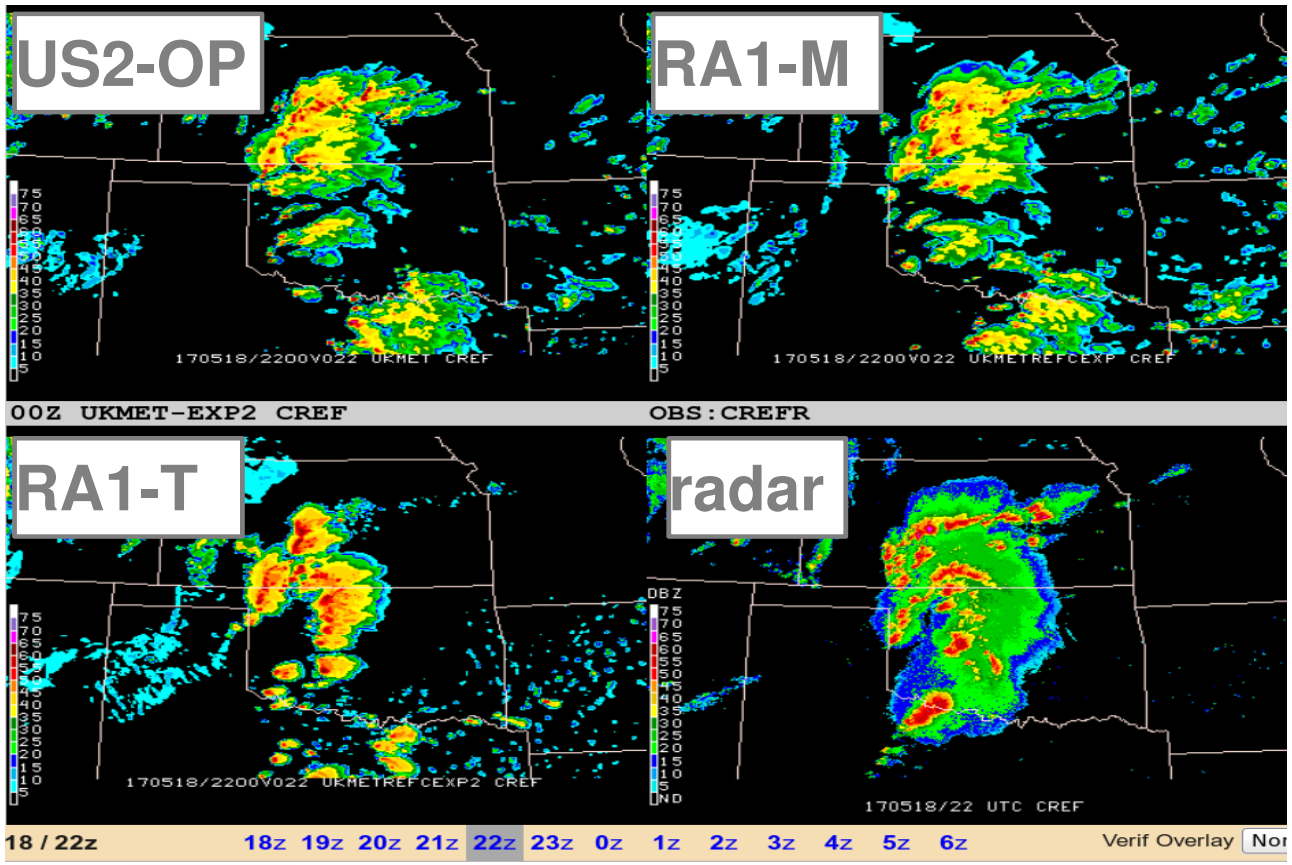

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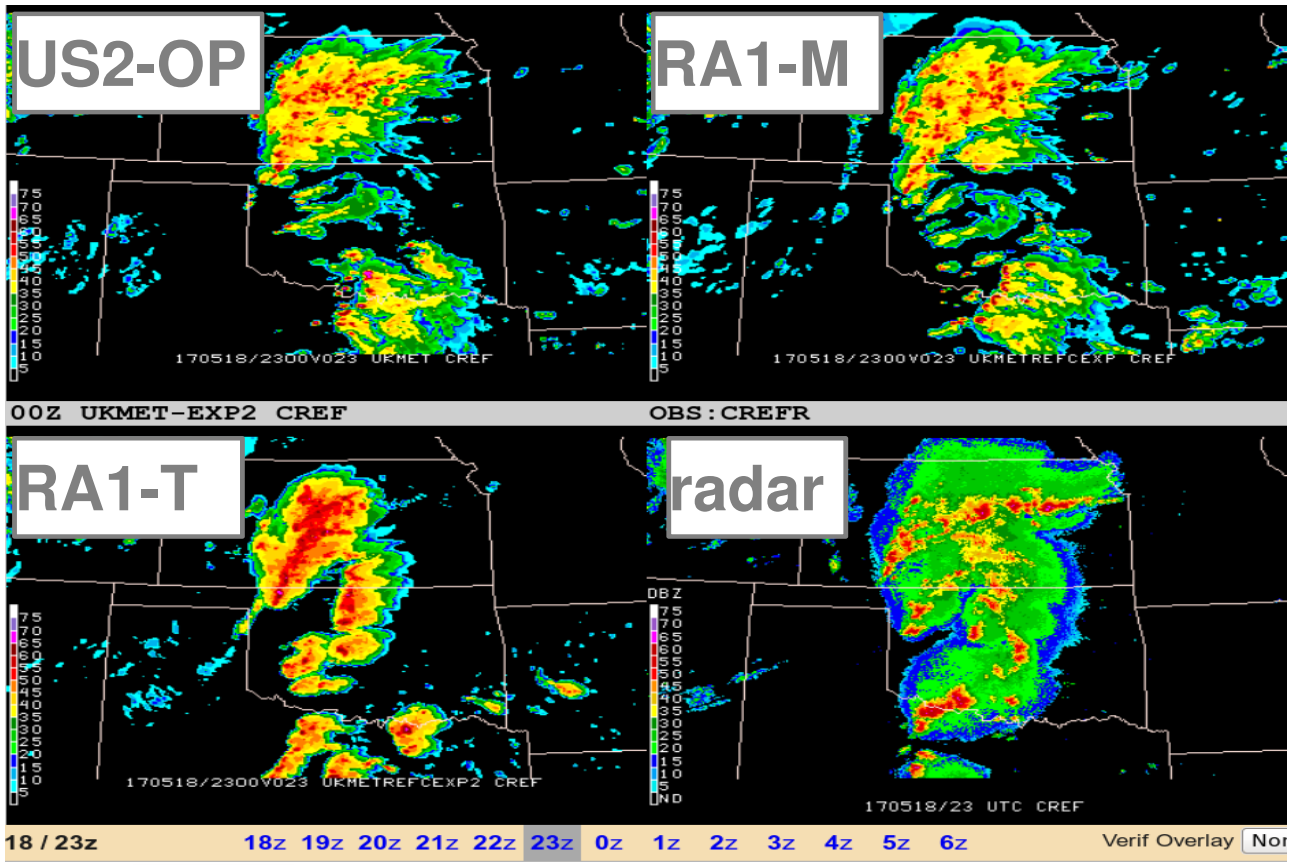

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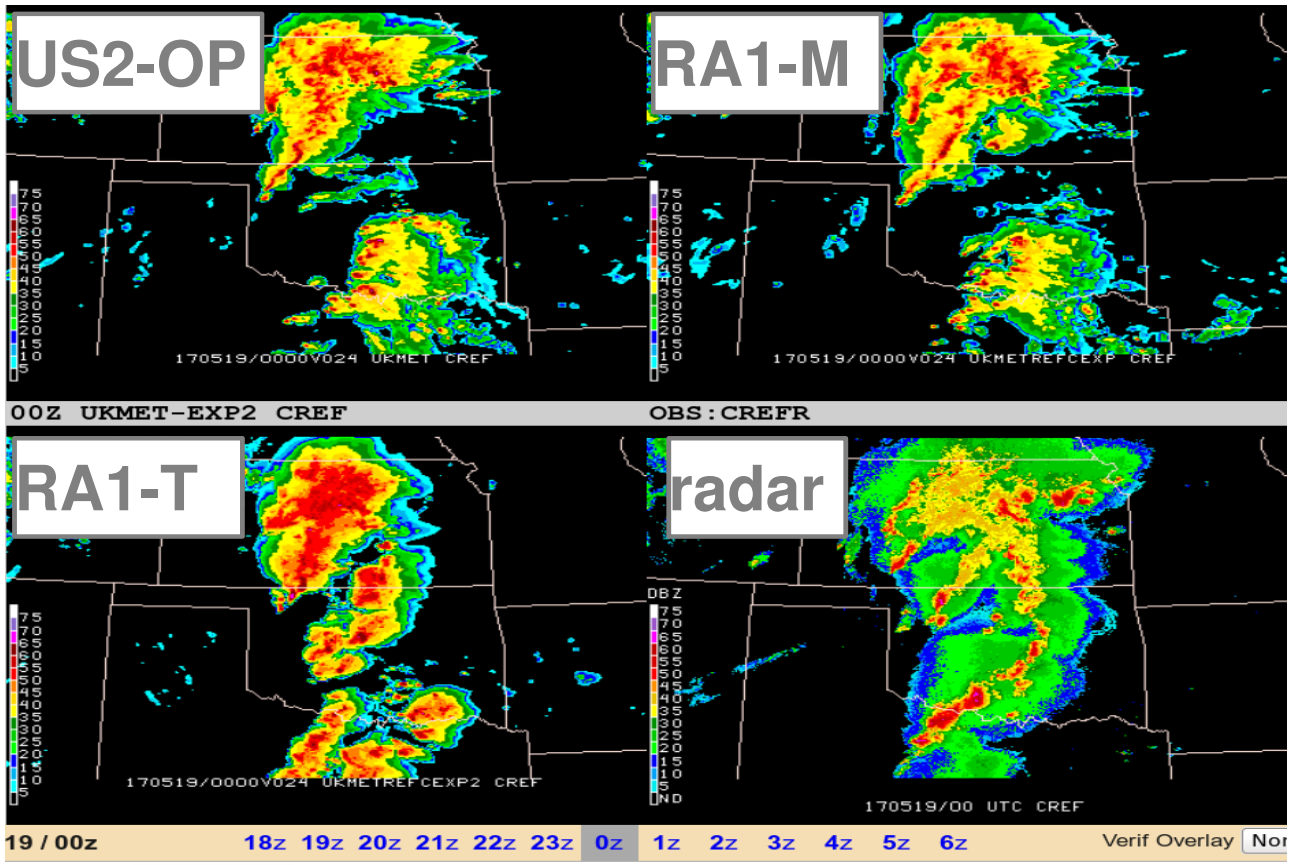

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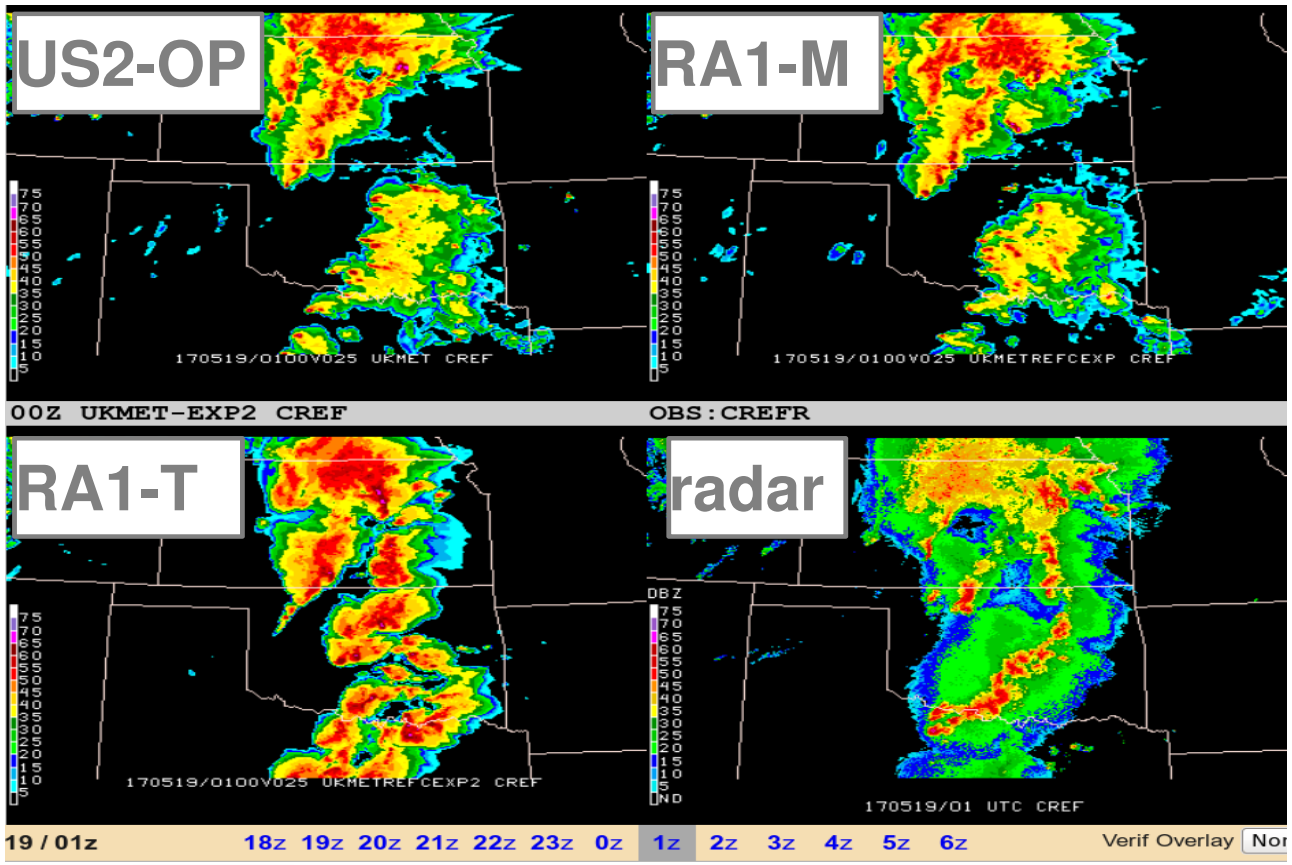

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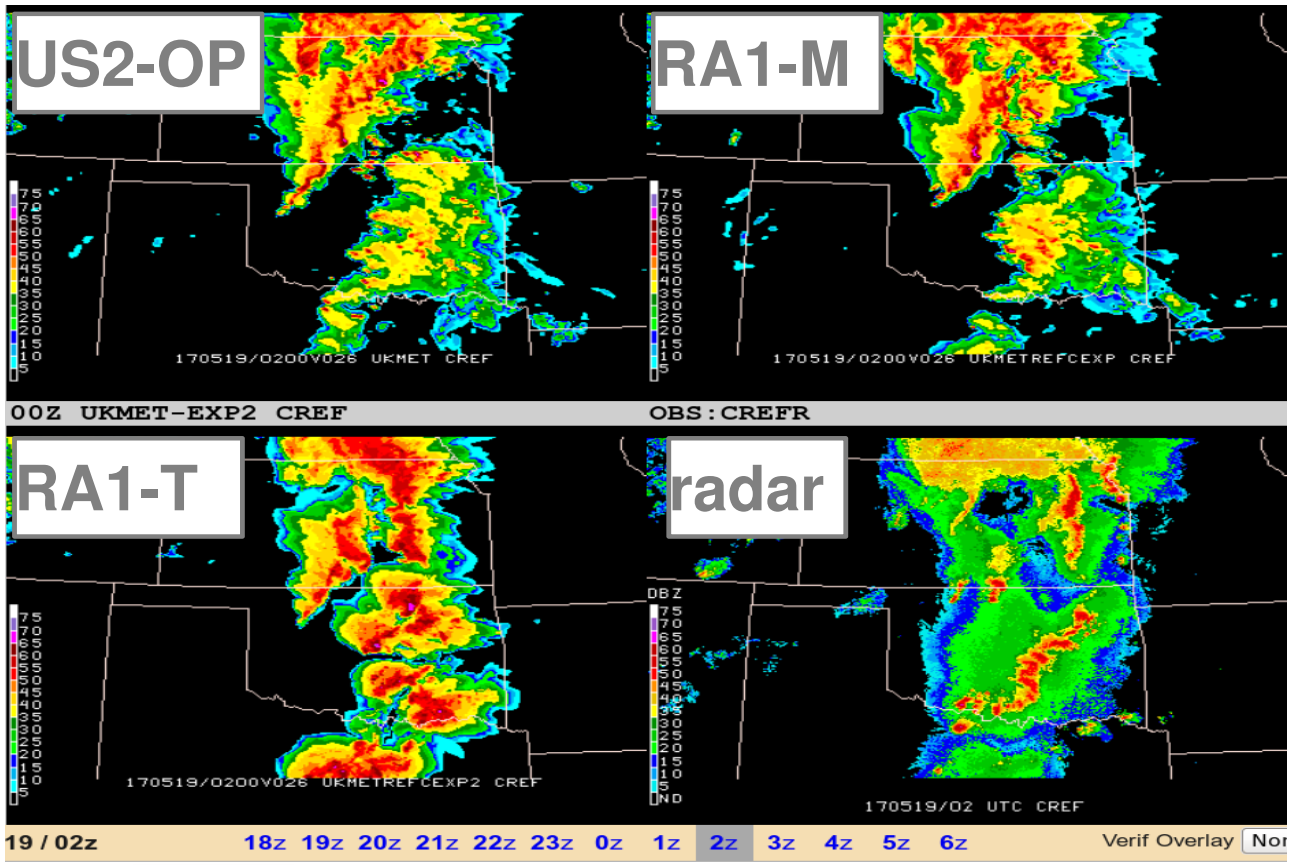

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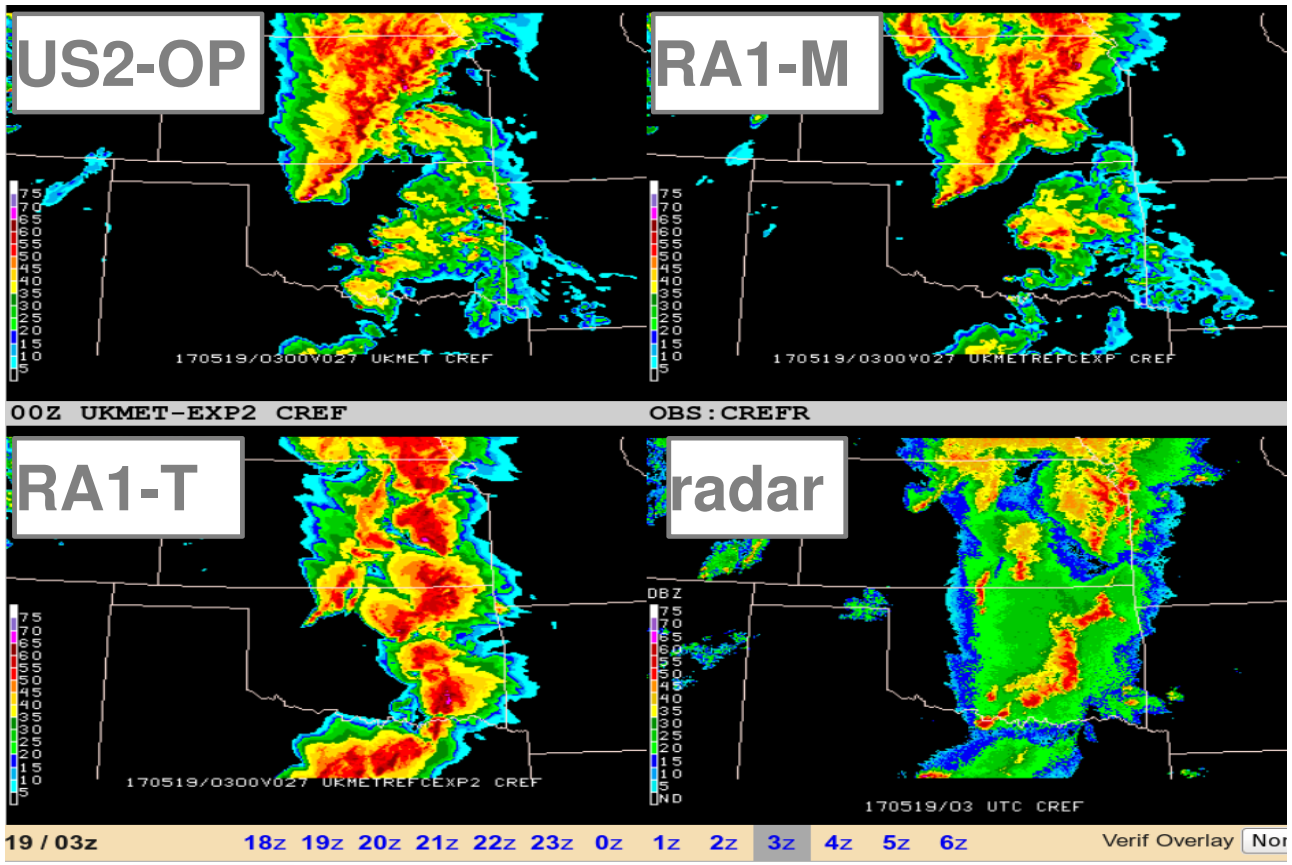

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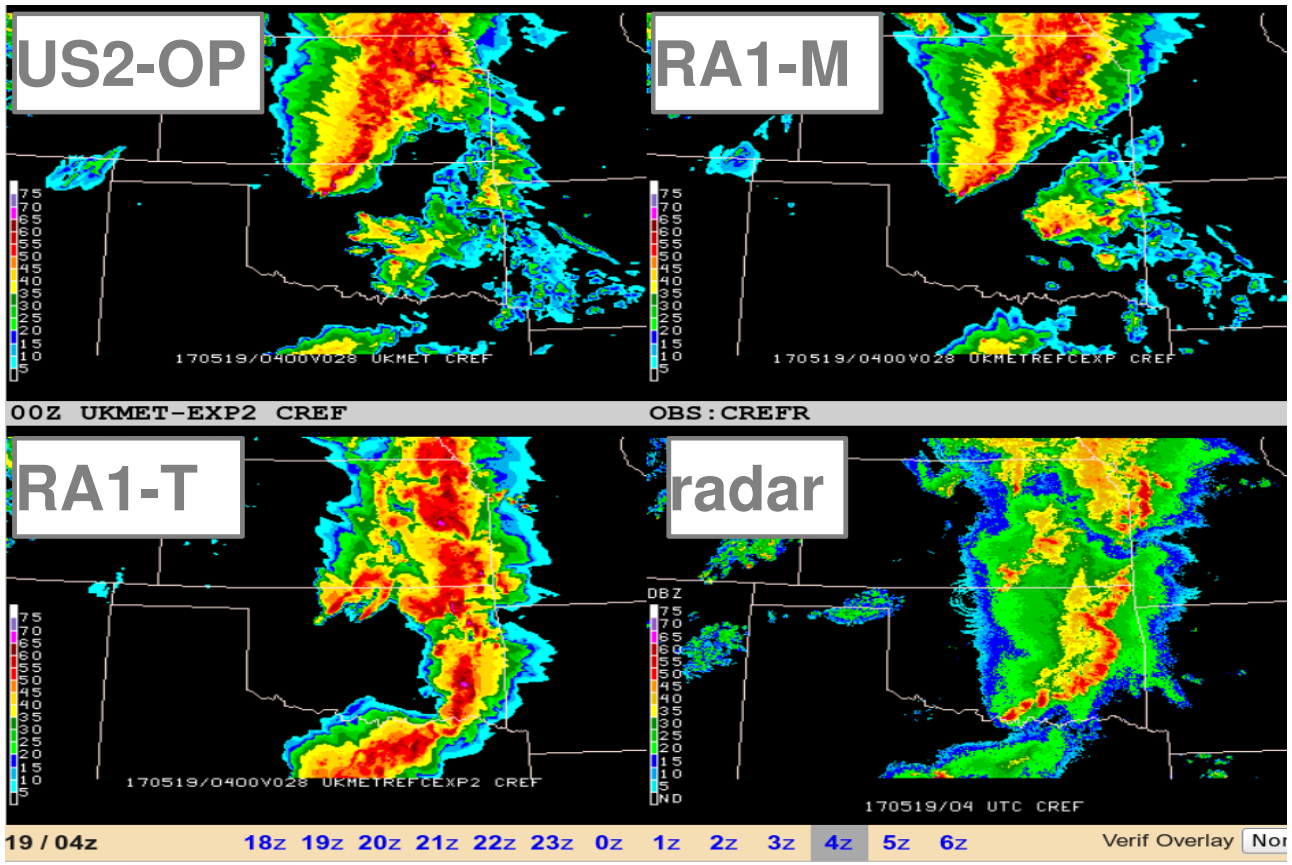

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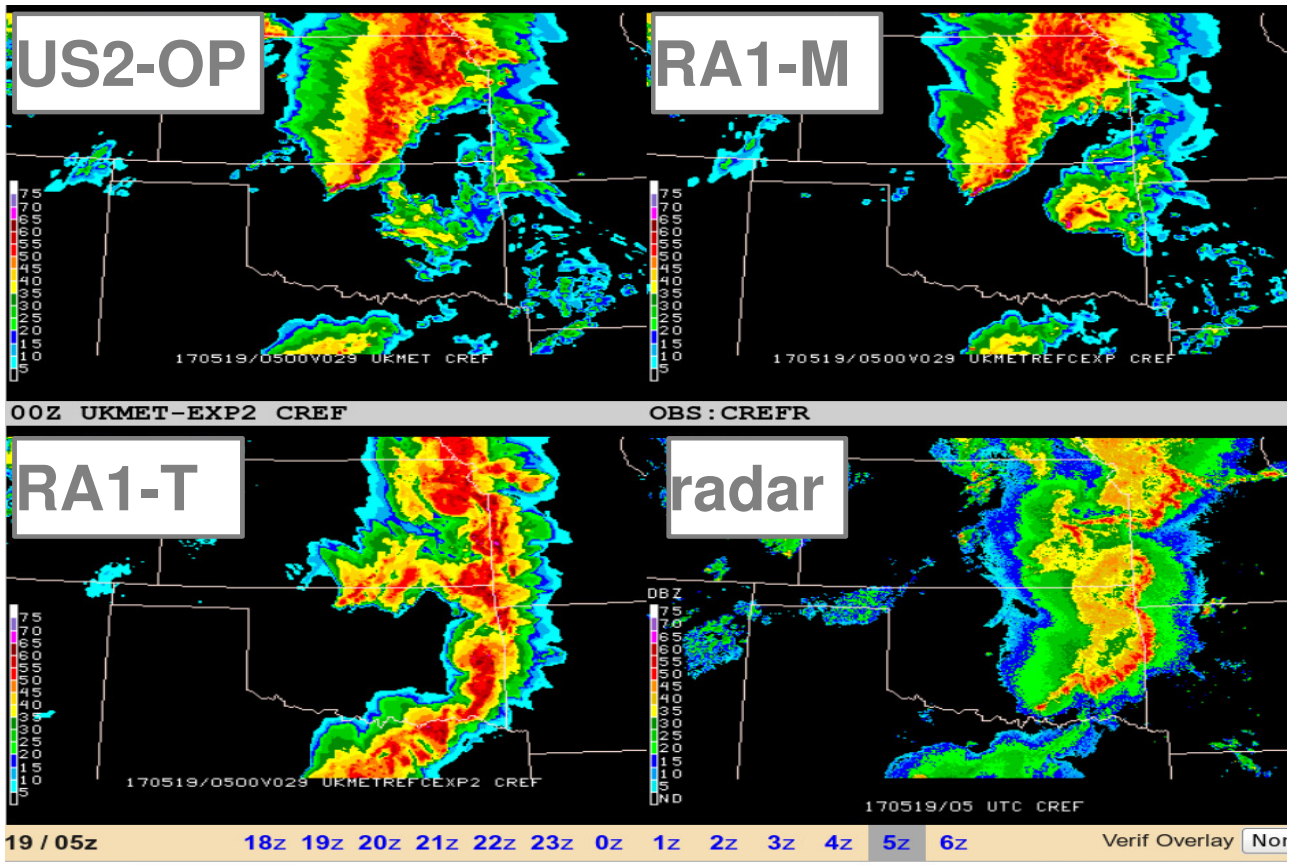

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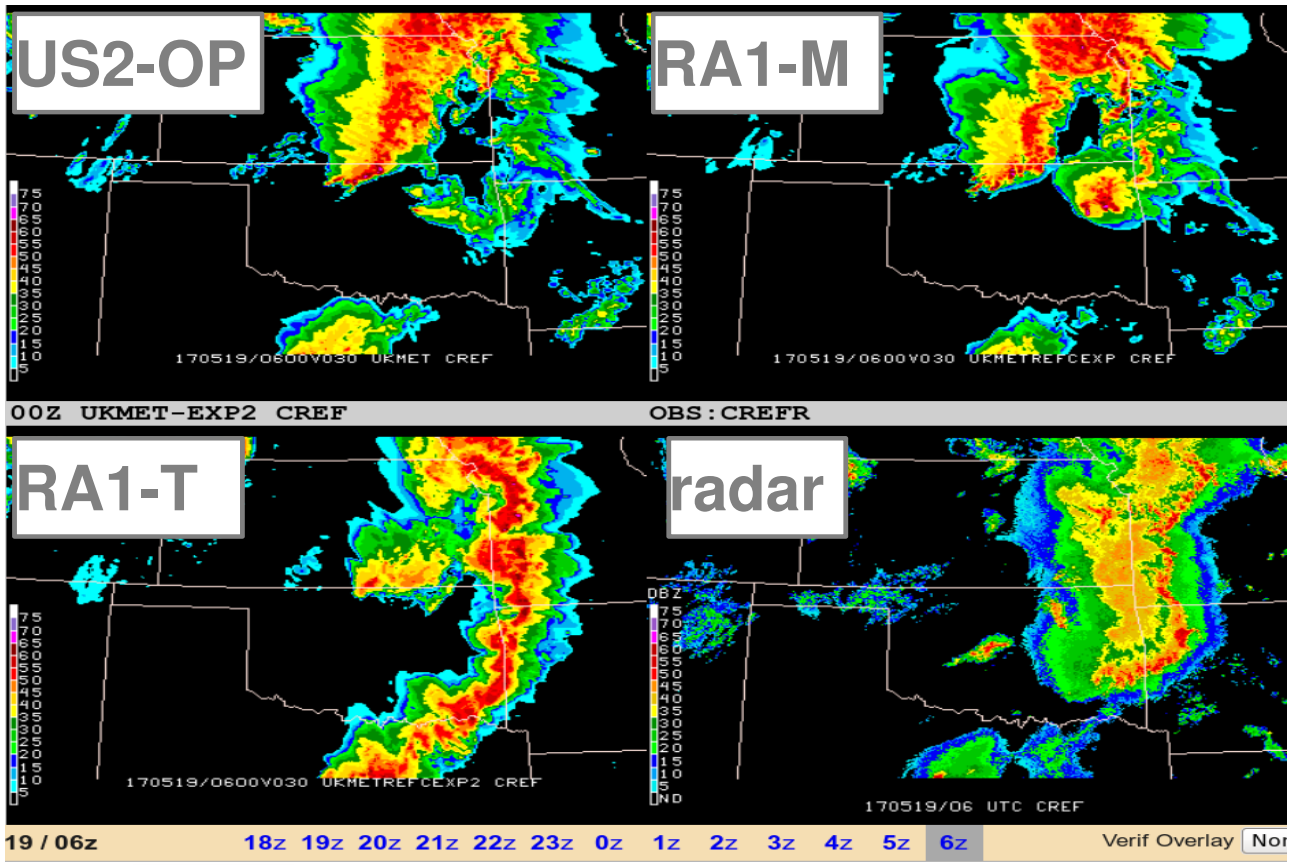


Met Office

May 27, 2017 2000 UTC Day 1 Convective Outlook

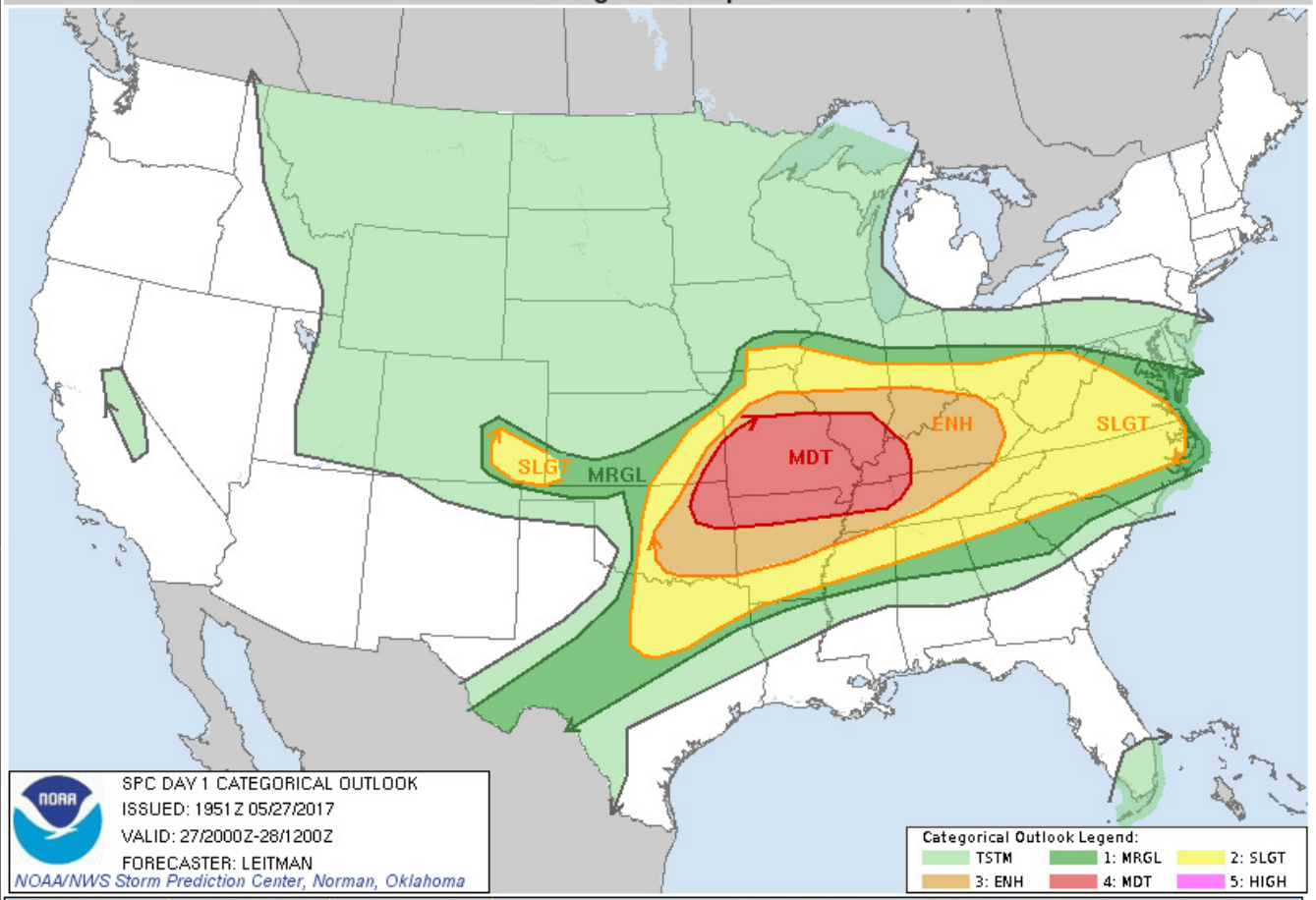
Updated: Sat May 27 19:51:17 UTC 2017 (|)

Probabilistic to Categorical Outlook Conversion Table

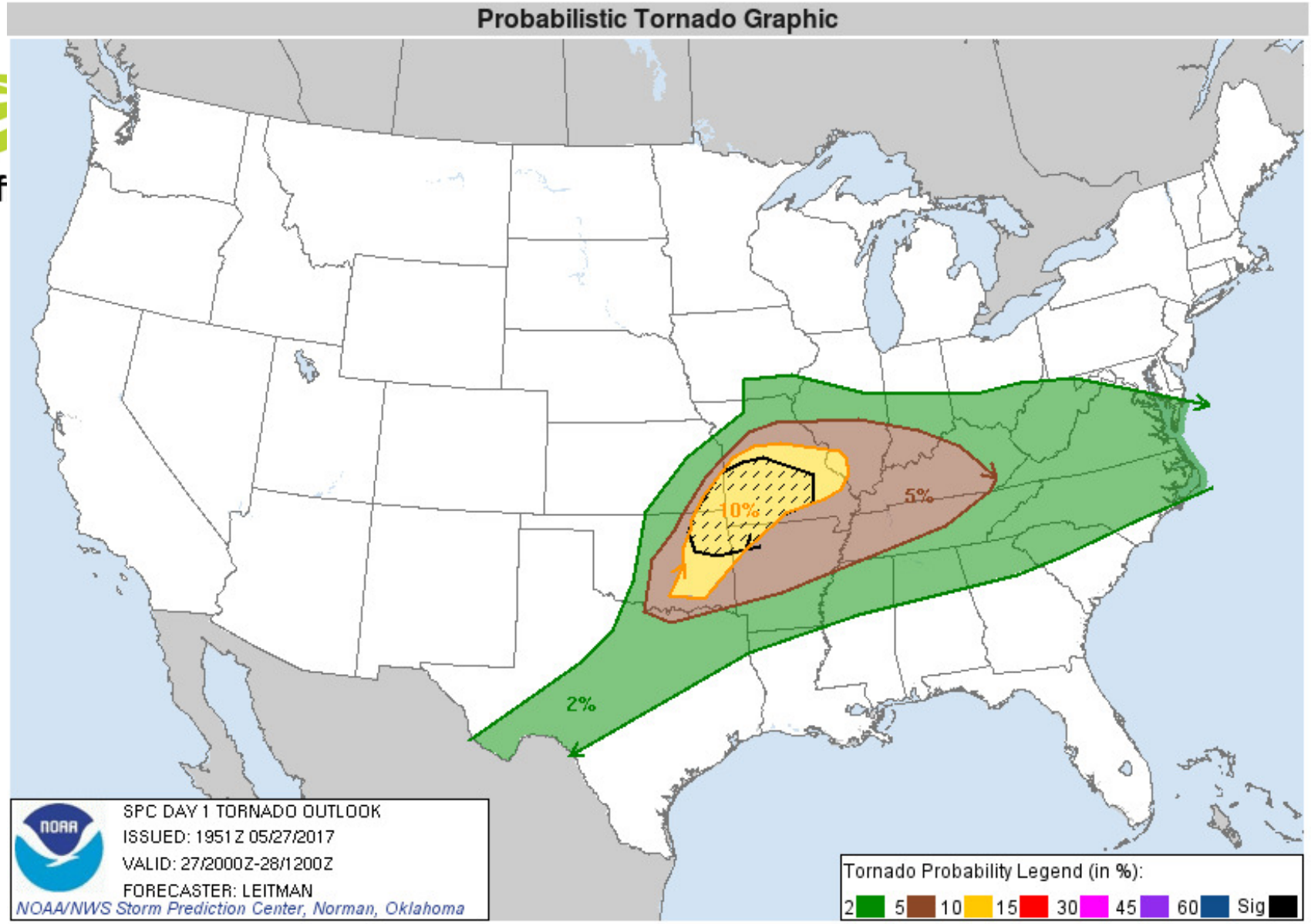
Public Severe Weather Outlook

The SPC is forecasting ...Severe thunderstorms expected over parts of the Ozarks to lower Ohio Valley this afternoon and tonight.... Please **read** the latest public statement about this event. View What is a Watch? clip.

Categorical Graphic



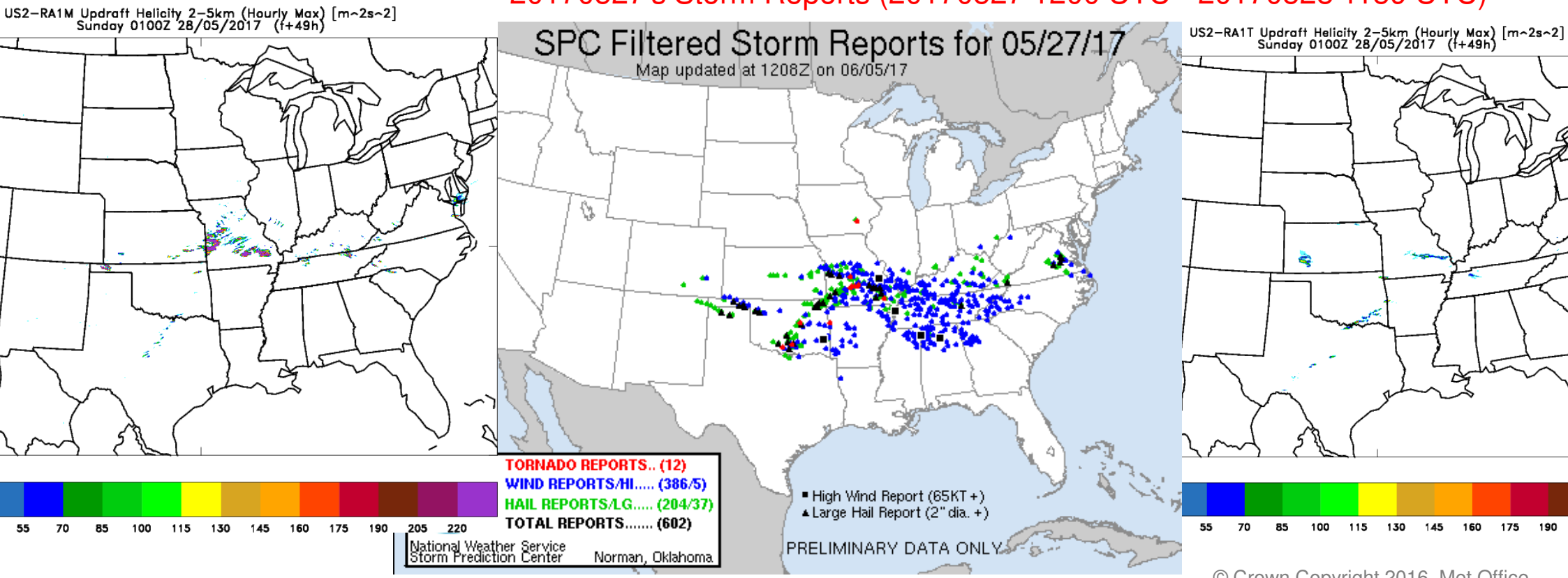
Day 1 Risk	Area (sq. mi.)	Area Pop.	Some Larger Population Centers in Risk Area
MODERATE	100,434	8,690,660	Tulsa, OK...St. Louis, MO...Springfield, MO...Clarksville, TN...Columbia, MO...
ENHANCED	120,565	11,582,569	Memphis, TN...Oklahoma City, OK...Nashville, TN...Lexington-Fayette, KY...Louisville, KY...
SLIGHT	290,897	39,712,336	Dallas, TX...Indianapolis, IN...Fort Worth, TX...Charlotte, NC...Kansas City, MO...
MARGINAL	193,869	20,182,971	Columbus, OH...Virginia Beach, VA...Atlanta, GA...Wichita, KS...Birmingham, AL...



Probability of a tornado within 25 miles of a point.
Hatched Area: 10% or greater probability of EF2 - EF5 tornadoes within 25 miles of a point.

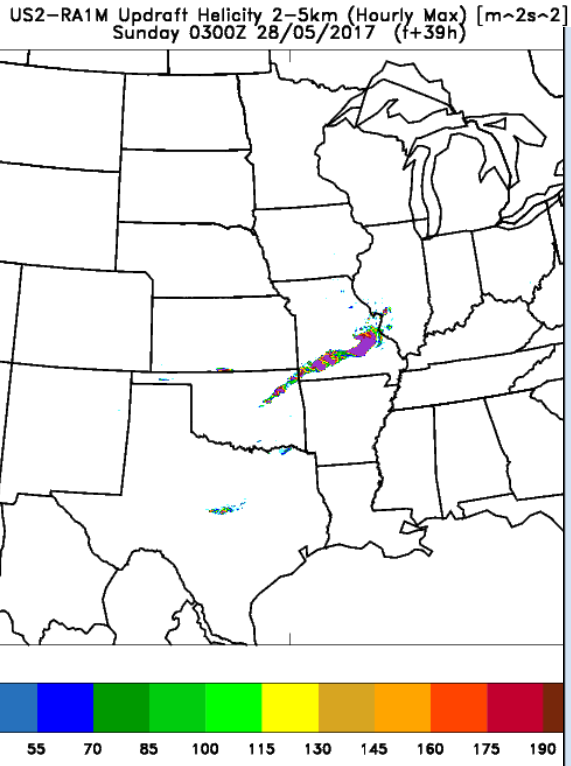
28 May 2017: Updraft Helicity

RA1-M	SPC storm reports	RA1-T

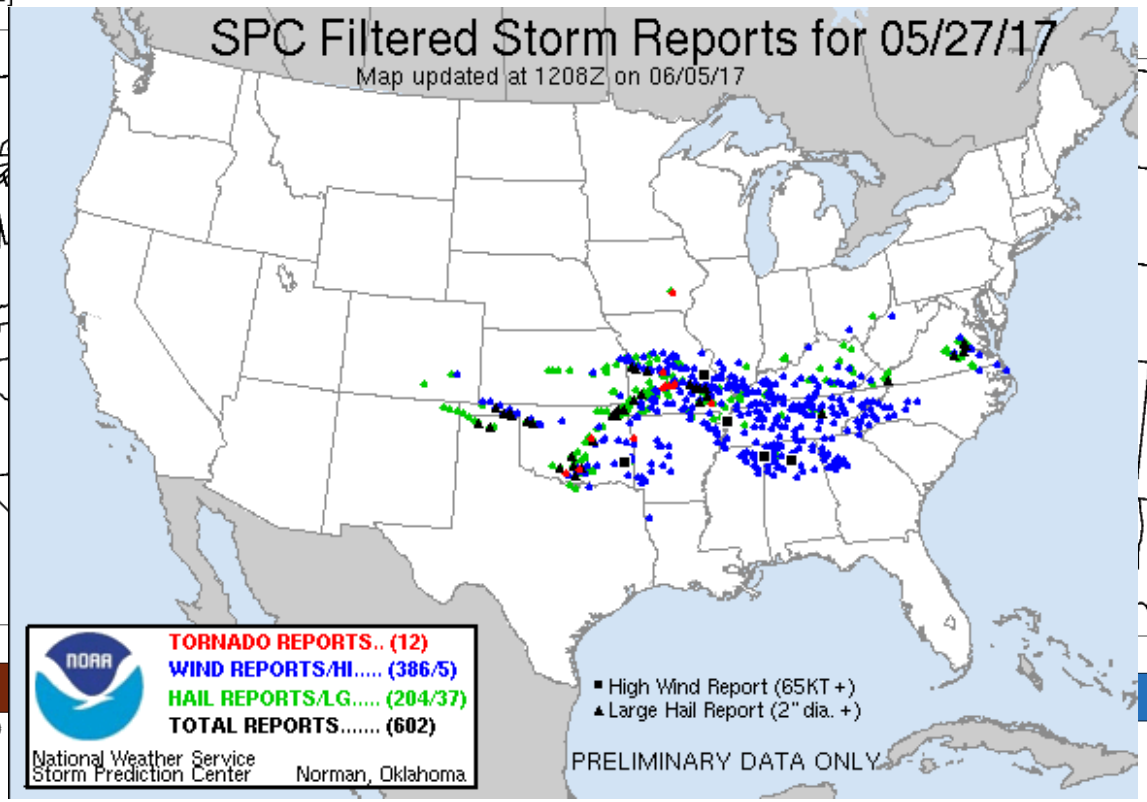


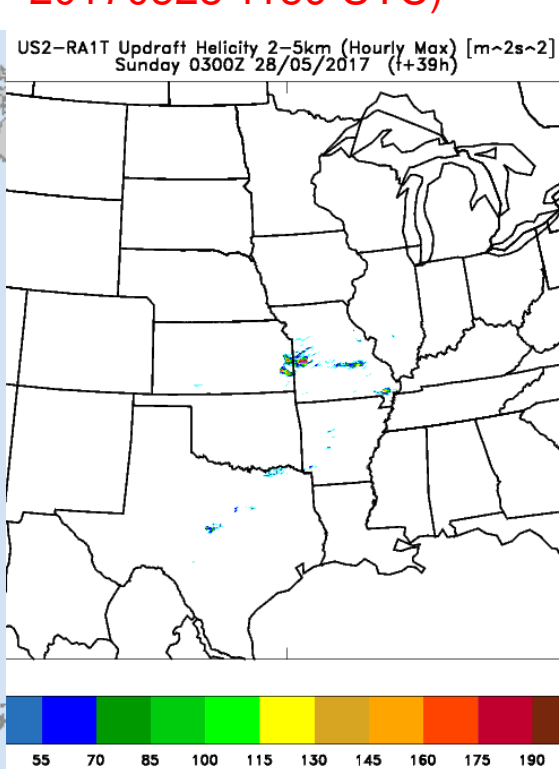
28 May 2017: Updraft Helicity

RA1-M	SPC storm reports	RA1-T



20170527's Storm Reports (20170527 1200 UTC - 20170528 1159 UTC)





Preliminary conclusions

• Updraft Helicity diagnostic seems to give reasonable guidance. When you see long coherent tracks that is a supercell signature. Stronger UH signal in RA1-M maybe because vertical velocities are greater than in RA1-T. Due to cloud scheme?

• proto RA1-M :


Initiation on time and precipitation and reflectivity better captured than RA1-T


Structure/mode not well captured

• proto RA1-T :


Structure/mode well captured


Initiation too late and precipitation/reflectivity too intense