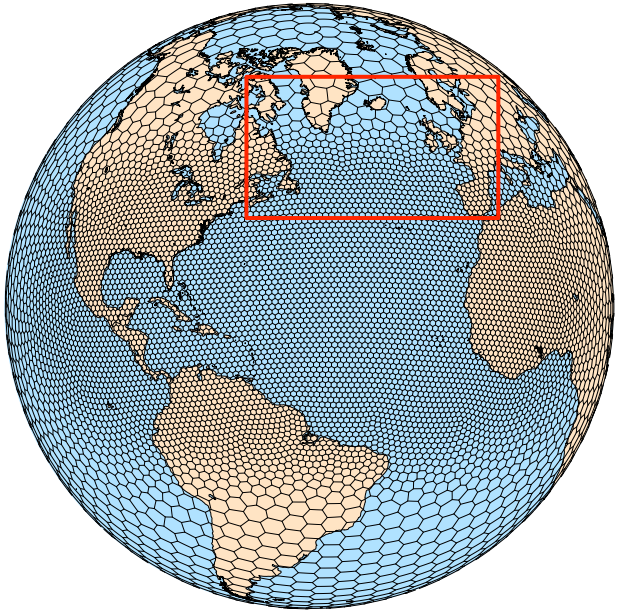
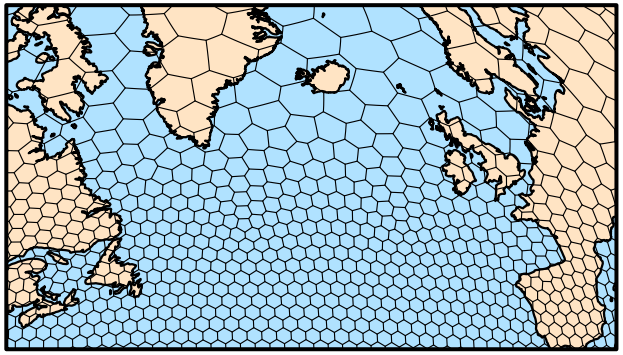
MPAS
Model for Prediction Across Scales

Convective-Scale Experimental Forecasts from the Global Variable-Resolution MPAS





MPAS consists of geophysical fluid-flow solvers based on unstructured centroidal Voronoi (hexagonal) meshes using C-grid staggering and selective grid refinement.

MPAS-Atmosphere:

- Nonhydrostatic global atmospheric model
- Time integration as in Advanced Research WRF
- Spatial discretization similar to ARW except for Voronoi mesh accommodations.

NCAR: David Ahijevych, Michael Duda, Laura Fowler, Bill Skamarock, Wei Wang, May Wong
HWT Spring Experiment at the NWC
Lou Wicker (NSSL), Steven Cavallo (OU), Adam Clark (NSSL)

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MPAS
Model for Prediction Across Scales

Hazardous Weather Testbed Spring Experiment 2015, 2016

Forecasts Results from MPAS

Application Test

NOAA SPC/NSSL HWT

May 2015, May 2016

Convective Forecast Experiment

Daily 5-day MPAS forecasts

00 UTC GFS analysis initialization

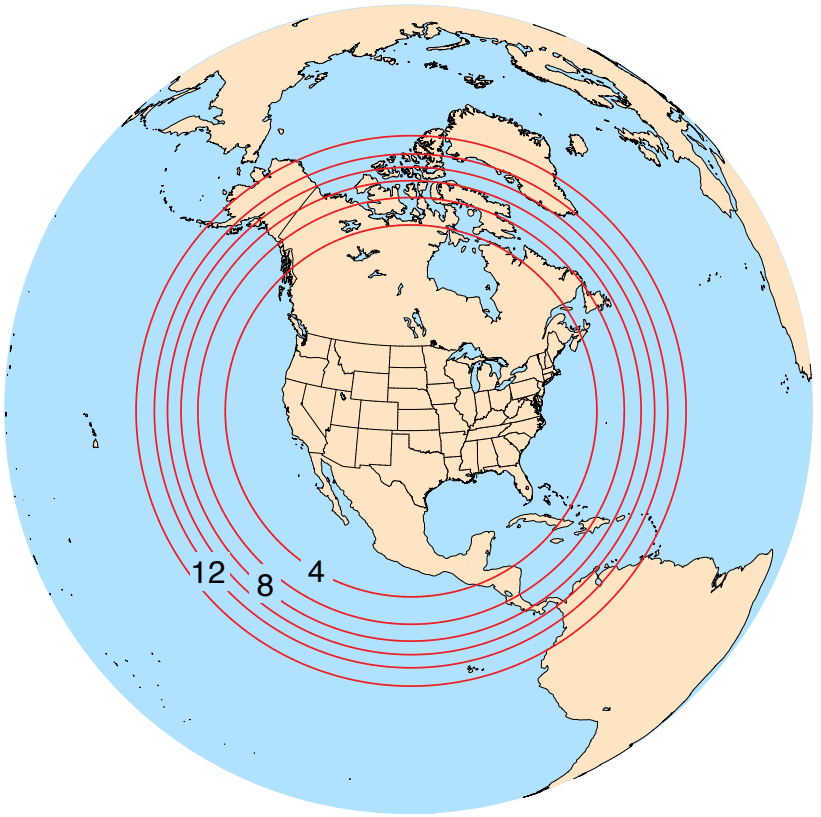
Application question:

Can a global variable-resolution convection permitting model provide extended range severe weather guidance?

Modeling question:

Will the physics behave appropriately in the different regions of the mesh (coarse, fine, and transition region)?

MPAS 2016 mesh



3-15 km mesh, dx contours 4, 6, 8, 10, 12, 14 km
approximately 6.49 million cells (horz.)
50% have < 4 km spacing
(194 pentagons, 182 septagons)

MPAS
Model for Prediction Across Scales

Hazardous Weather Testbed
Spring Experiment 2015, 2016
Forecasts Results from MPAS

MPAS meshes:

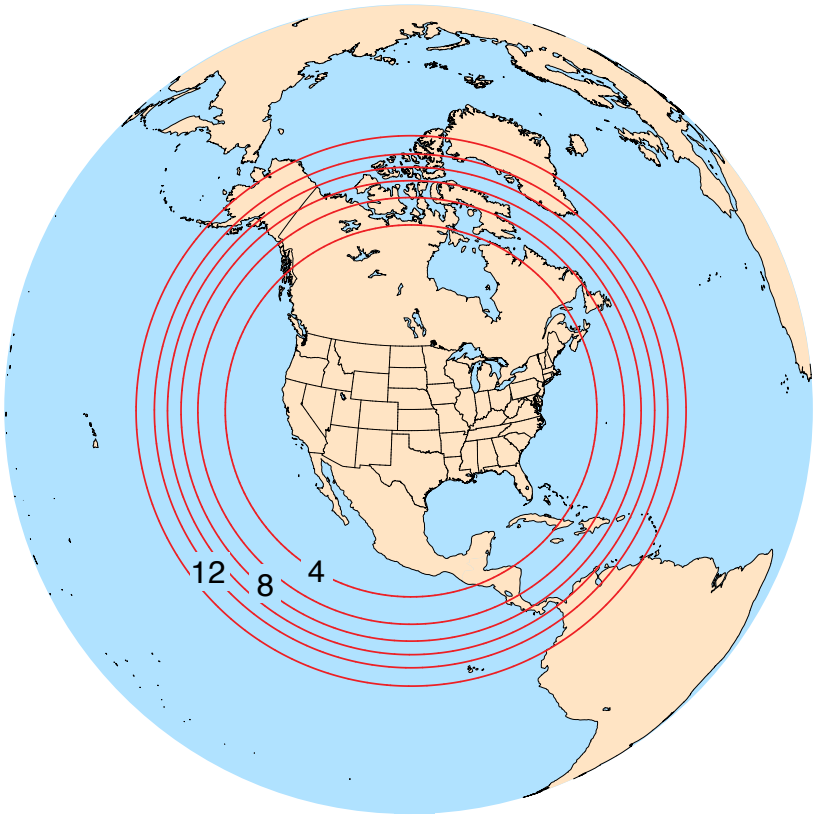
50 – 3 km (2015) and 15-3 km (2016) variable resolution.
CONUS is the 3 km regions.

MPAS Physics:

- *WSM6 cloud microphysics (2015)*
- *Thompson microphysics (2016)*
- Grell-Freitas convection scheme (scale-aware)
- Monin-Obukhov surface layer
- MYNN PBL
- Noah land-surface
- RRTMG lw and sw.

2015-2016: One step closer to the HRRR physics

MPAS 2016 mesh



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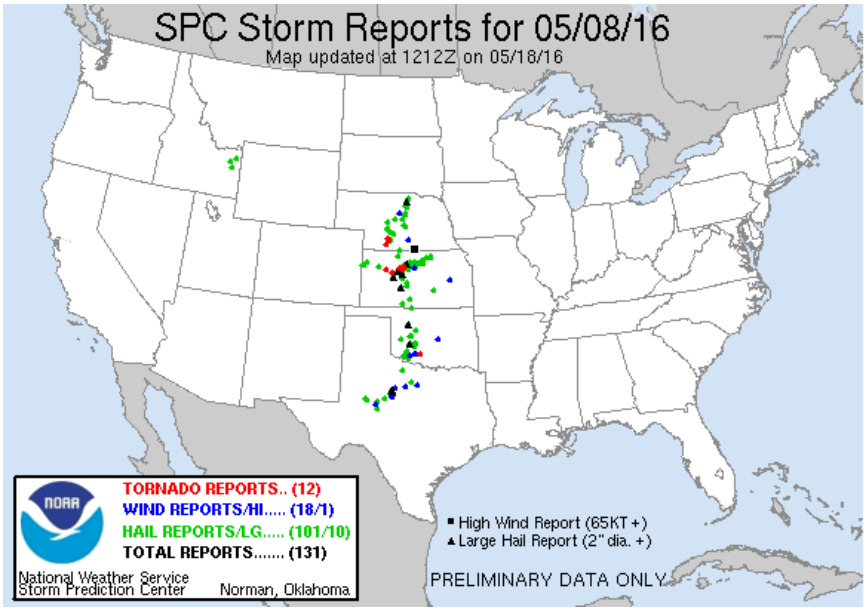
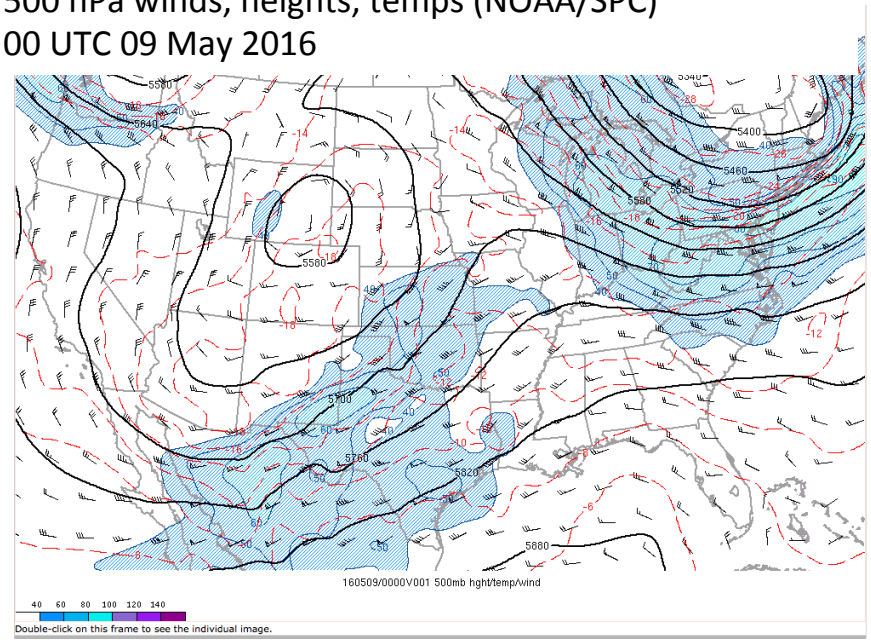
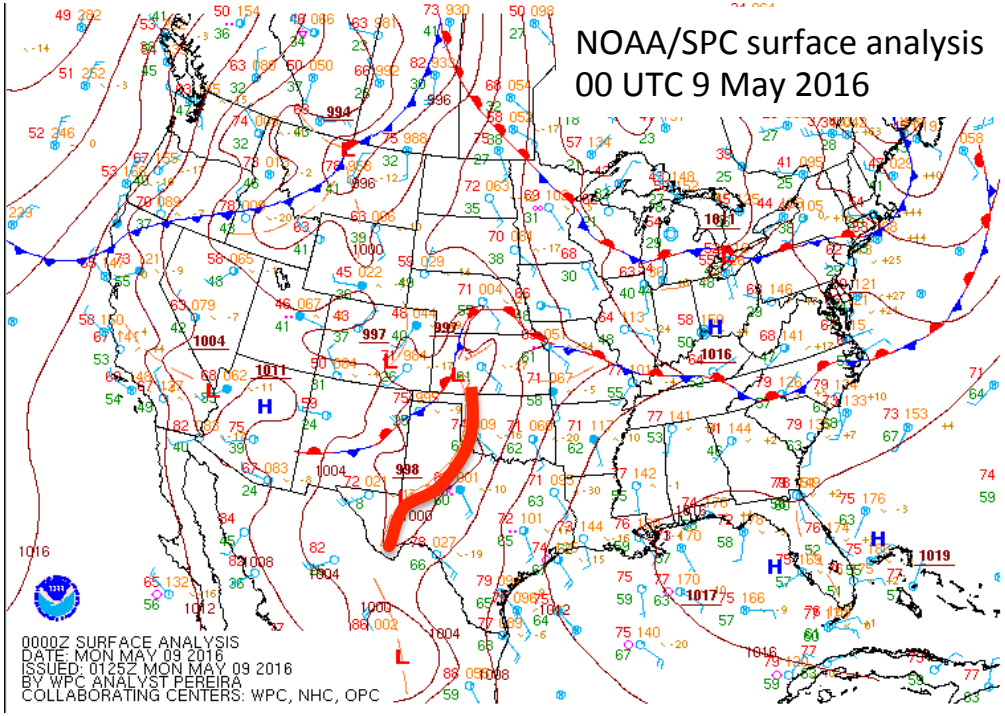


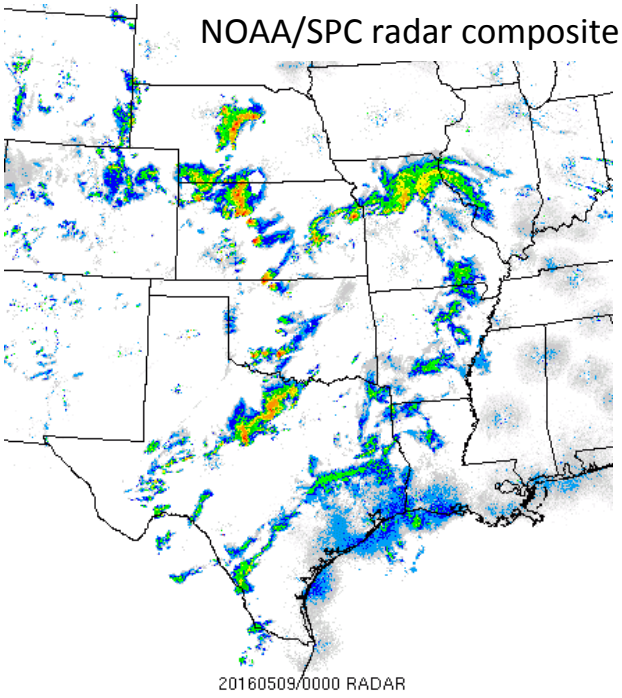
500 hPa winds, heights, temps (NOAA/SPC)
00 UTC 09 May 2016



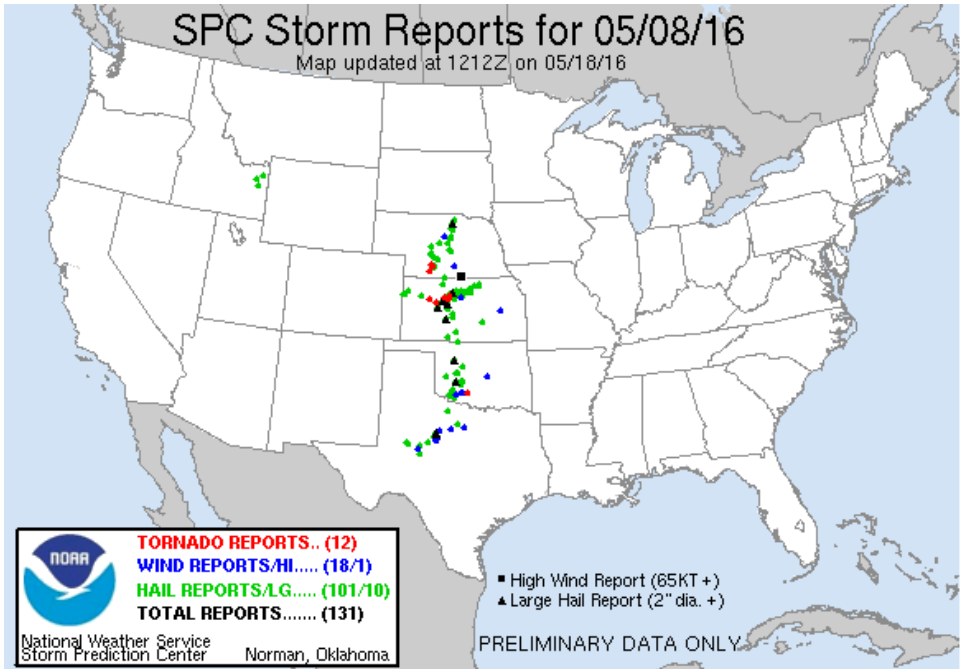
NOAA/SPC surface analysis
00 UTC 9 May 2016



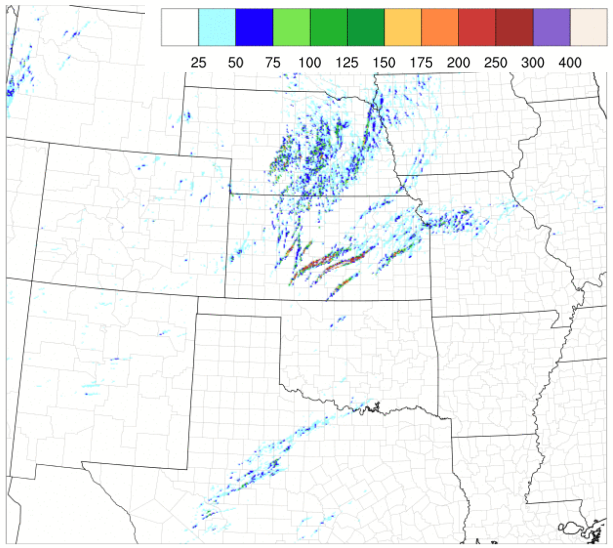
NOAA/SPC radar composite



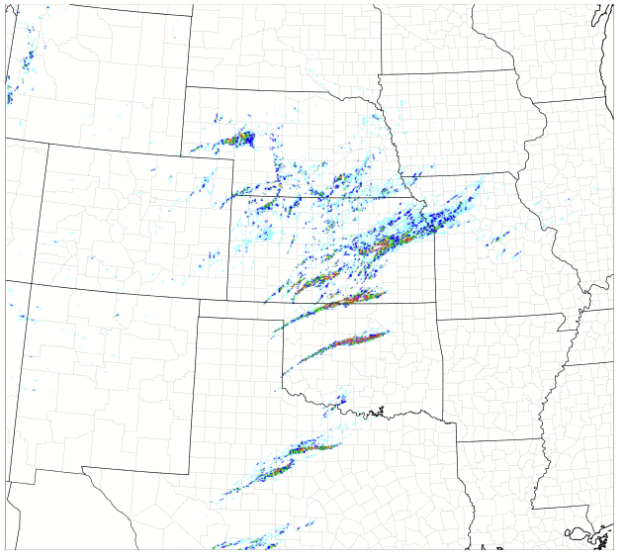
MPAS 24h Max Updraft Helicity (m^2/s^2)



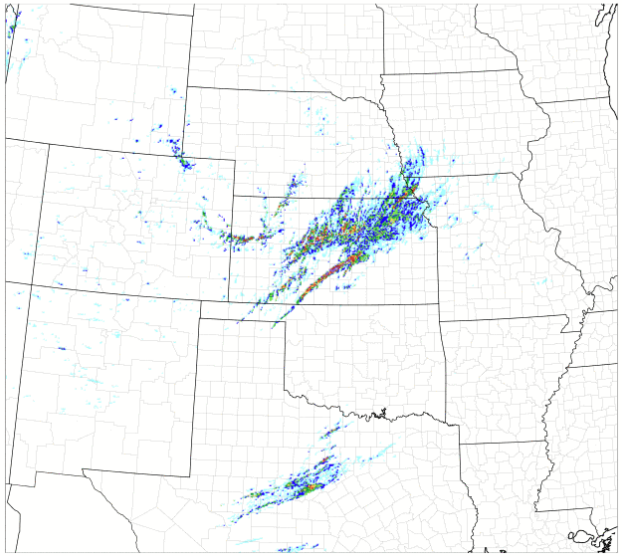
MPAS 36h forecast



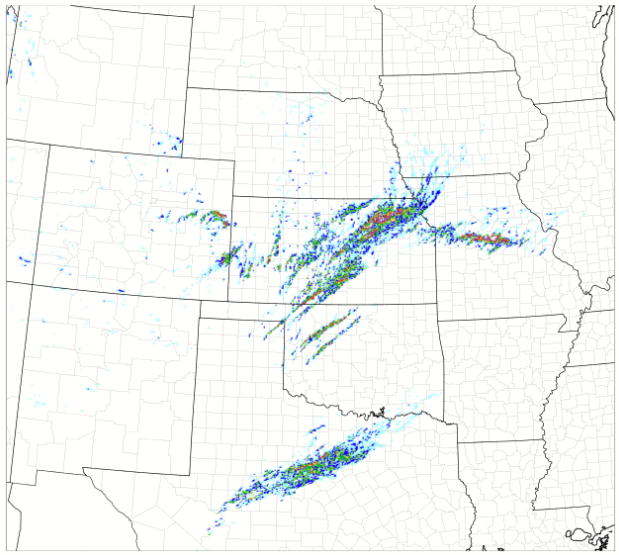
MPAS 60h forecast



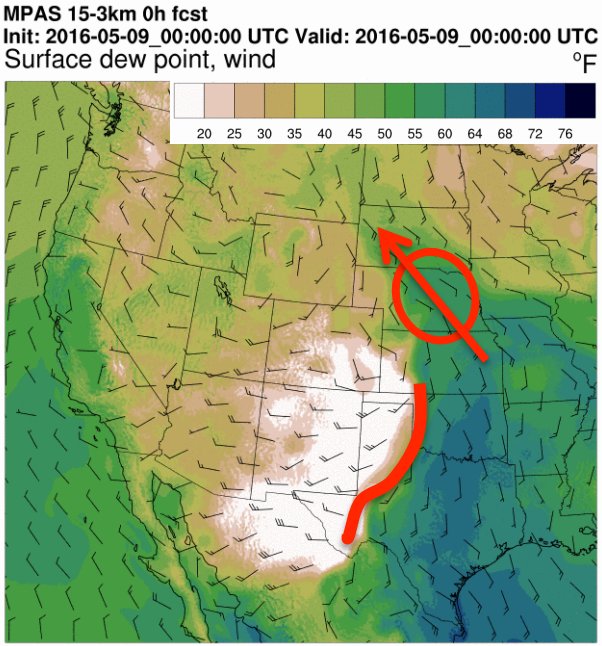
MPAS 84h forecast

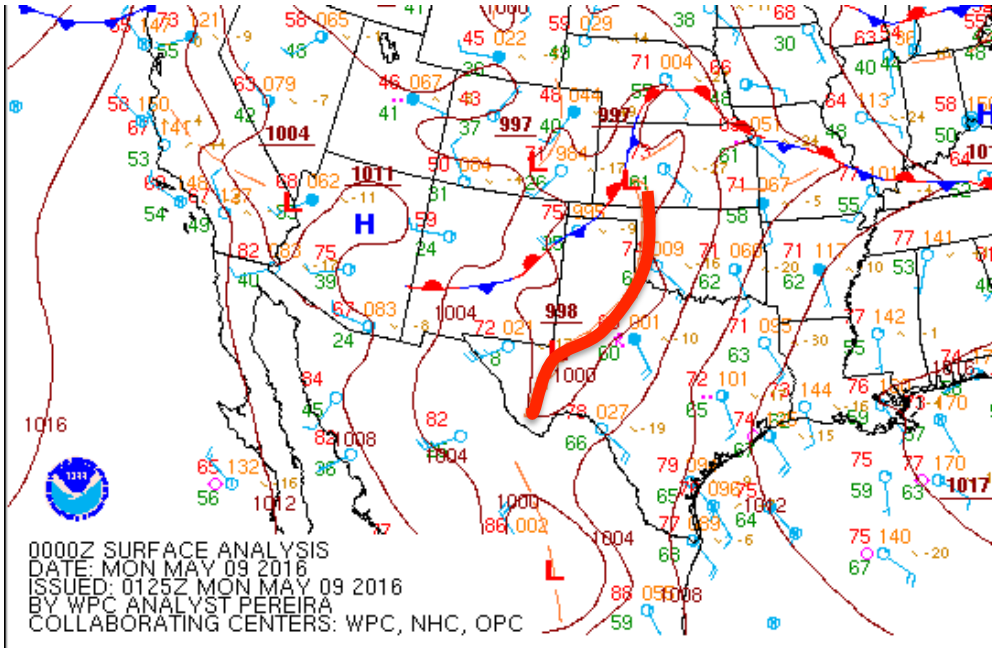


MPAS 108h forecast

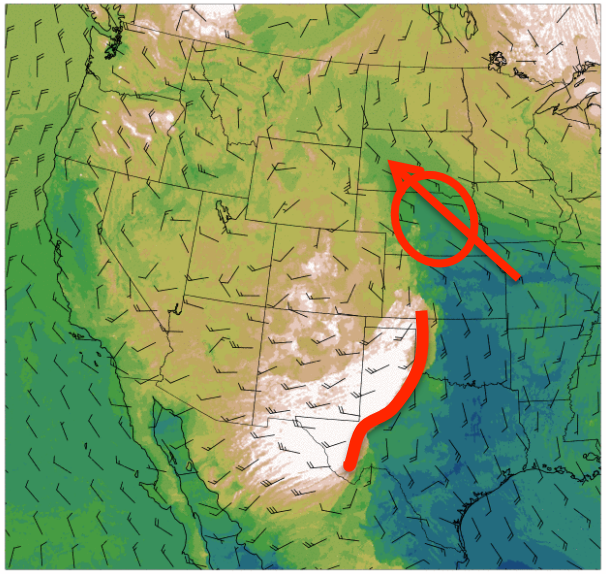


GFS analysis, 00 UTC 9 May 2016

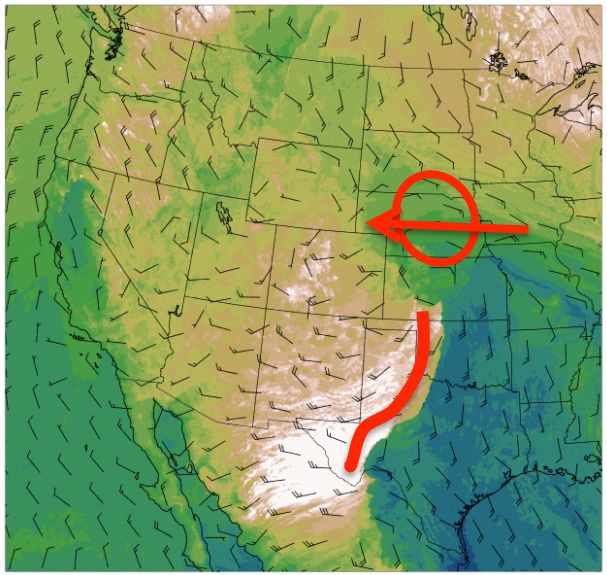




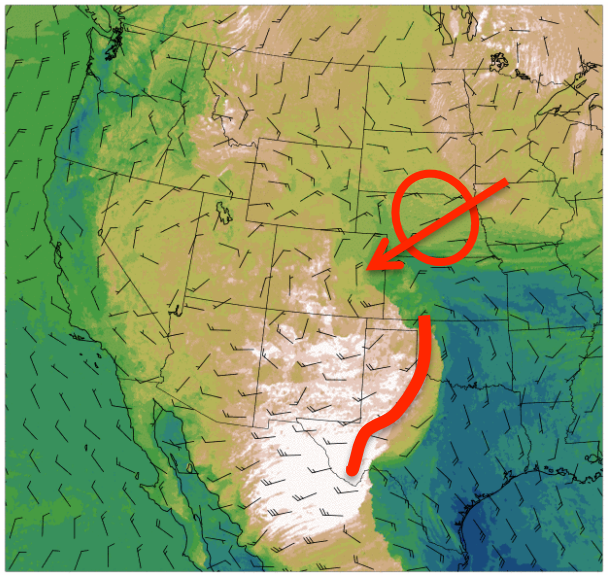
MPAS 24h forecast

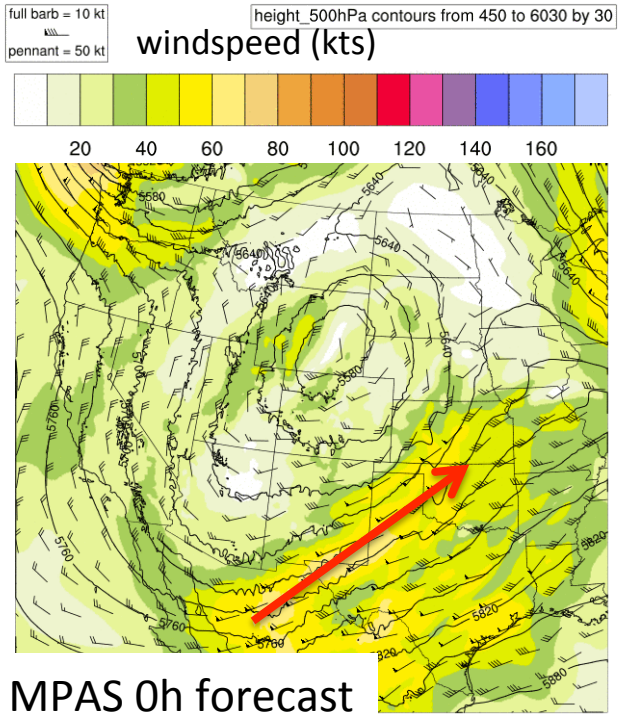


MPAS 72h forecast



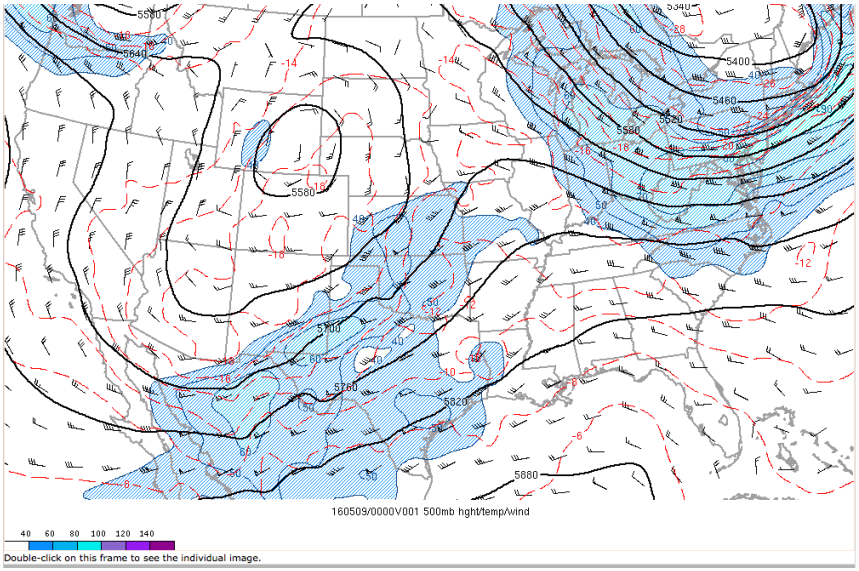
MPAS 120h forecast



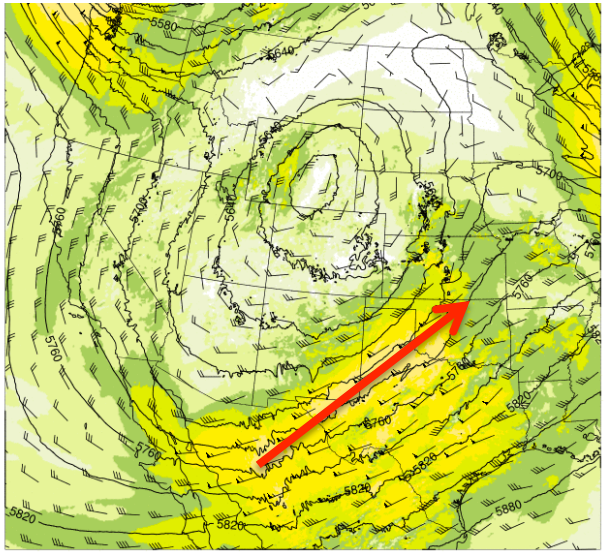


MPAS 0h forecast

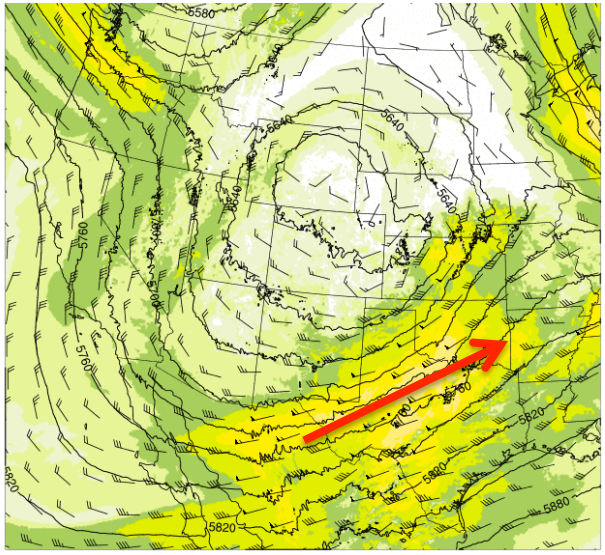
500 hPa winds, heights, temps (NOAA/SPC)
00 UTC 09 May 2016



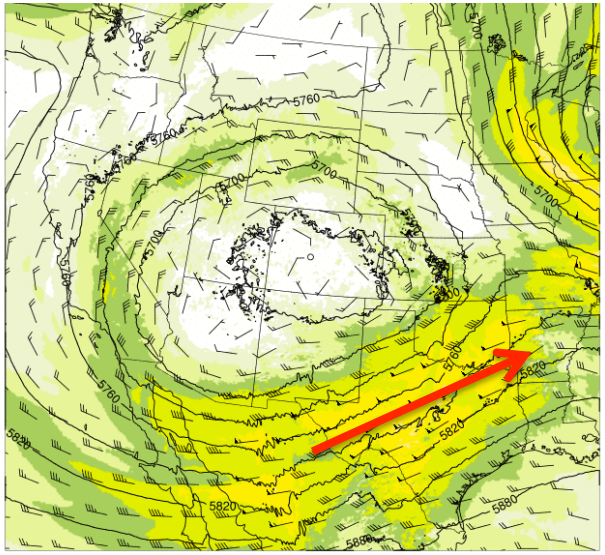
MPAS 24h forecast



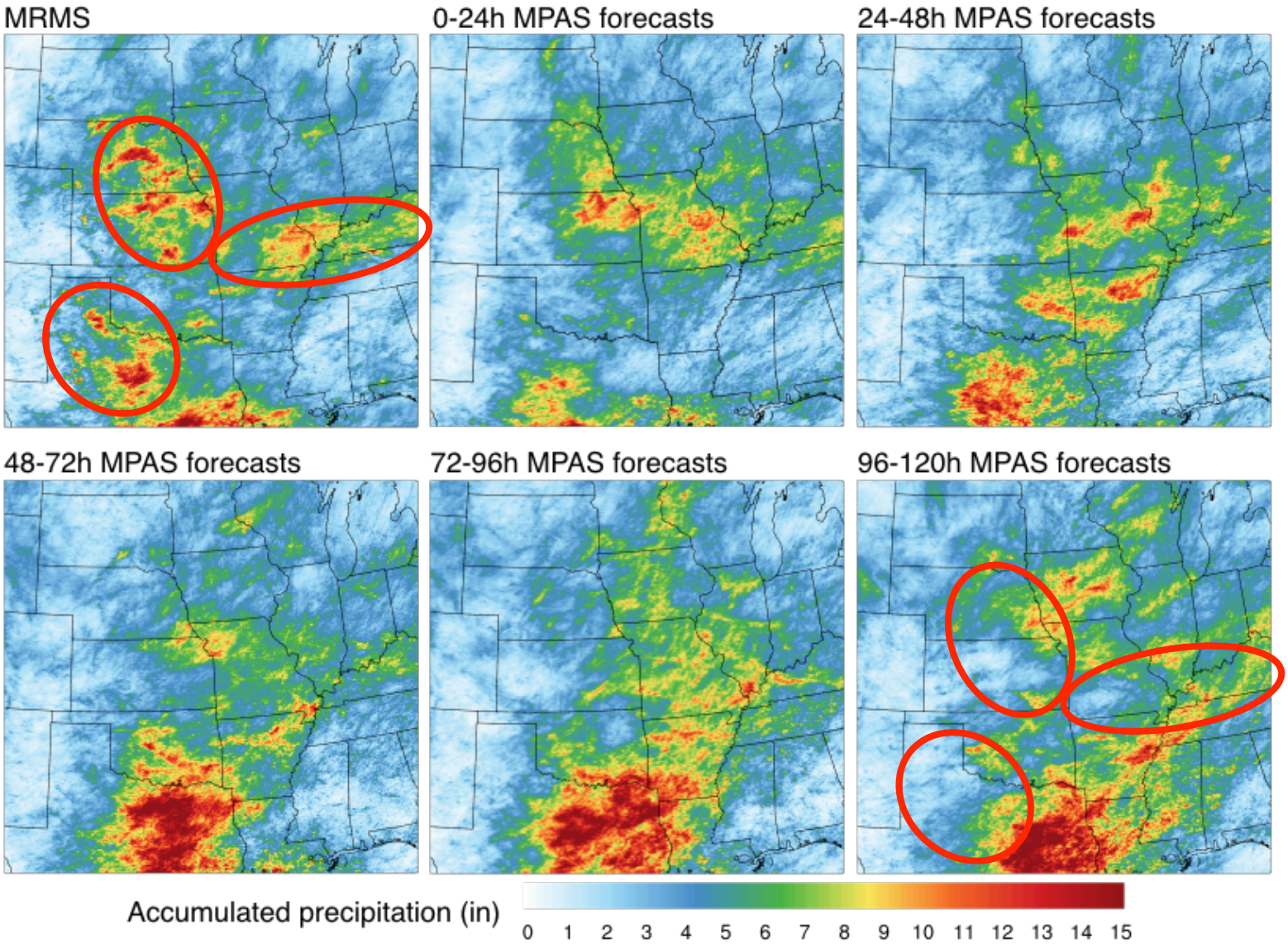
MPAS 72h forecast



MPAS 120h forecast



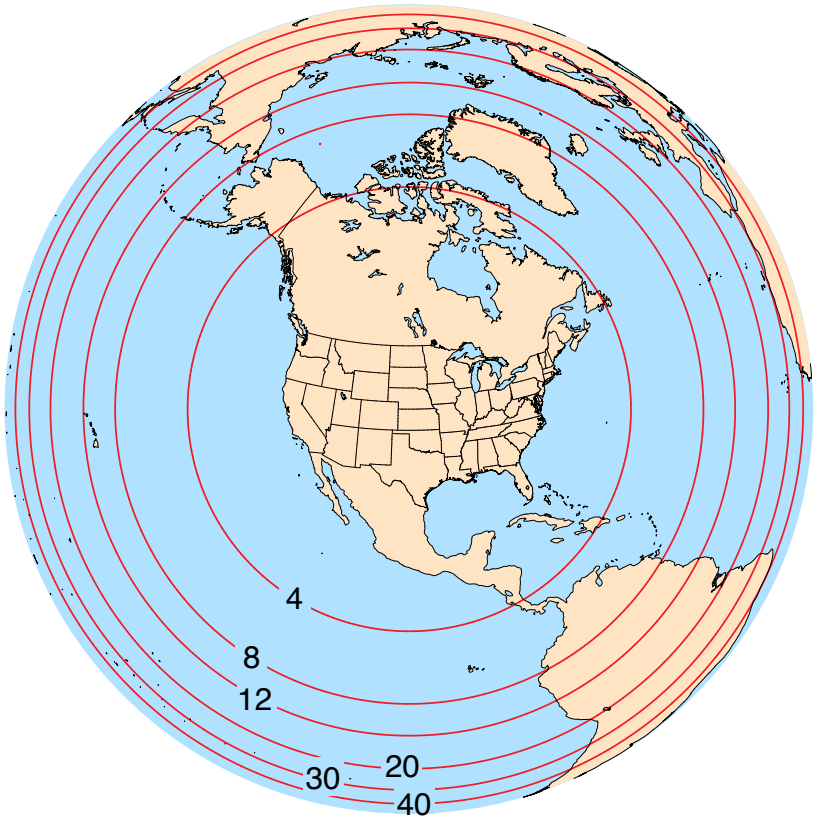
1-31 May 2016 Accumulated Precipitation
MRMS Analysis and MPAS Forecasts



MPAS
Model for Prediction Across Scales

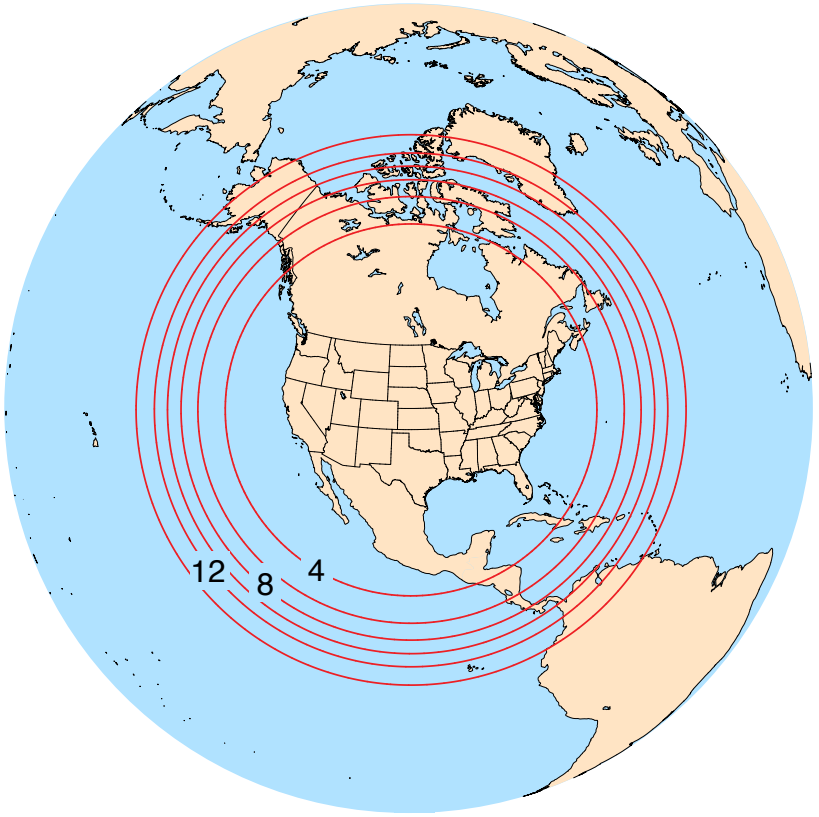
Hazardous Weather Testbed
Spring Experiment 2015, 2016
Forecasts Results from MPAS

MPAS 2015 mesh



3-50 km mesh, dx contours 4, 8, 12, 20, 30 40 km
approximately 6.85 million cells (horz.)
68% have < 4 km spacing
(158 pentagons, 146 septagons)

MPAS 2016 mesh



3-15 km mesh, dx contours 4, 6, 8, 10, 12, 14 km
approximately 6.49 million cells (horz.)
50% have < 4 km spacing
(194 pentagons, 182 septagons)

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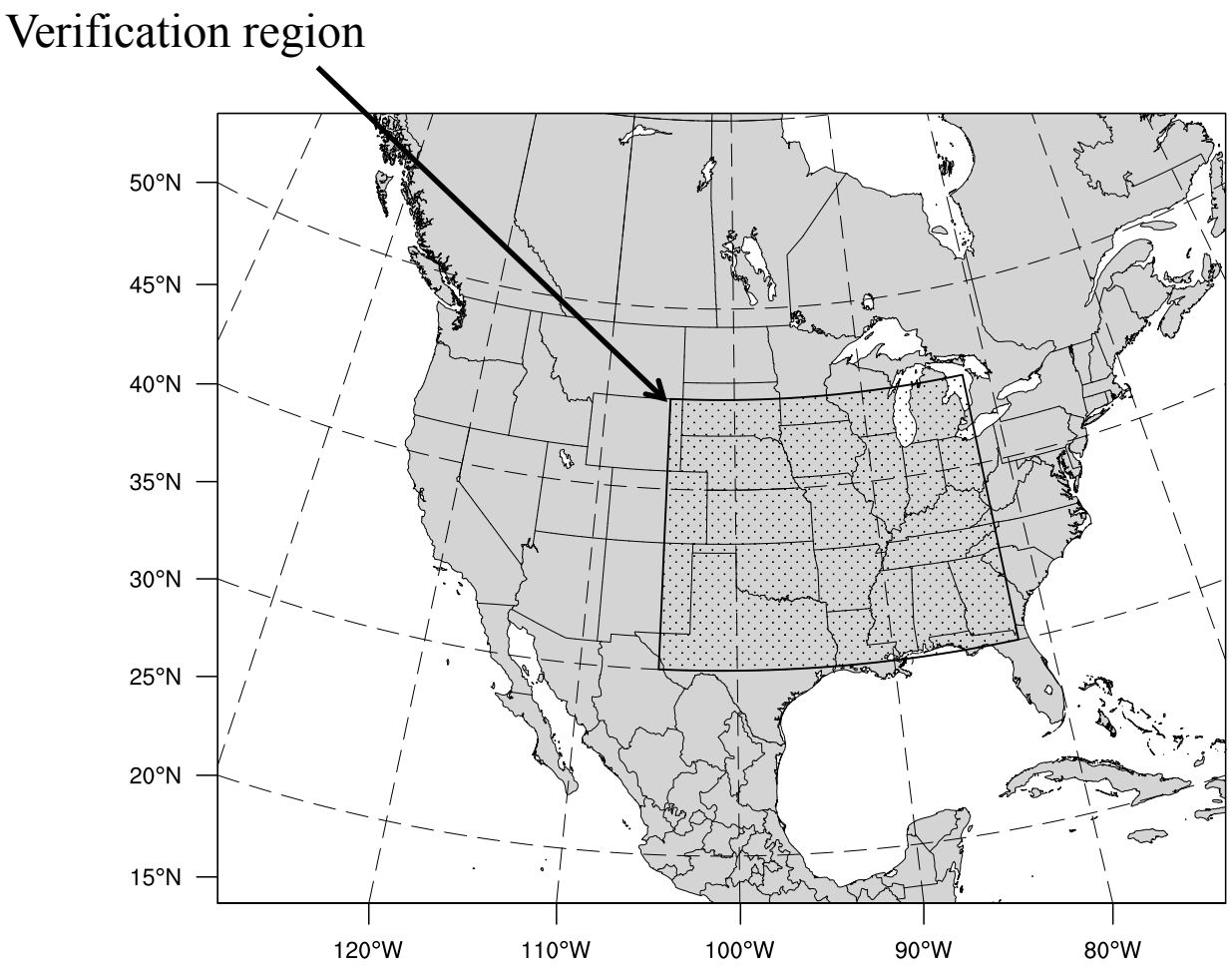
Hazardous Weather Testbed
Spring Experiment 2015, 2016
Forecasts Results from MPAS



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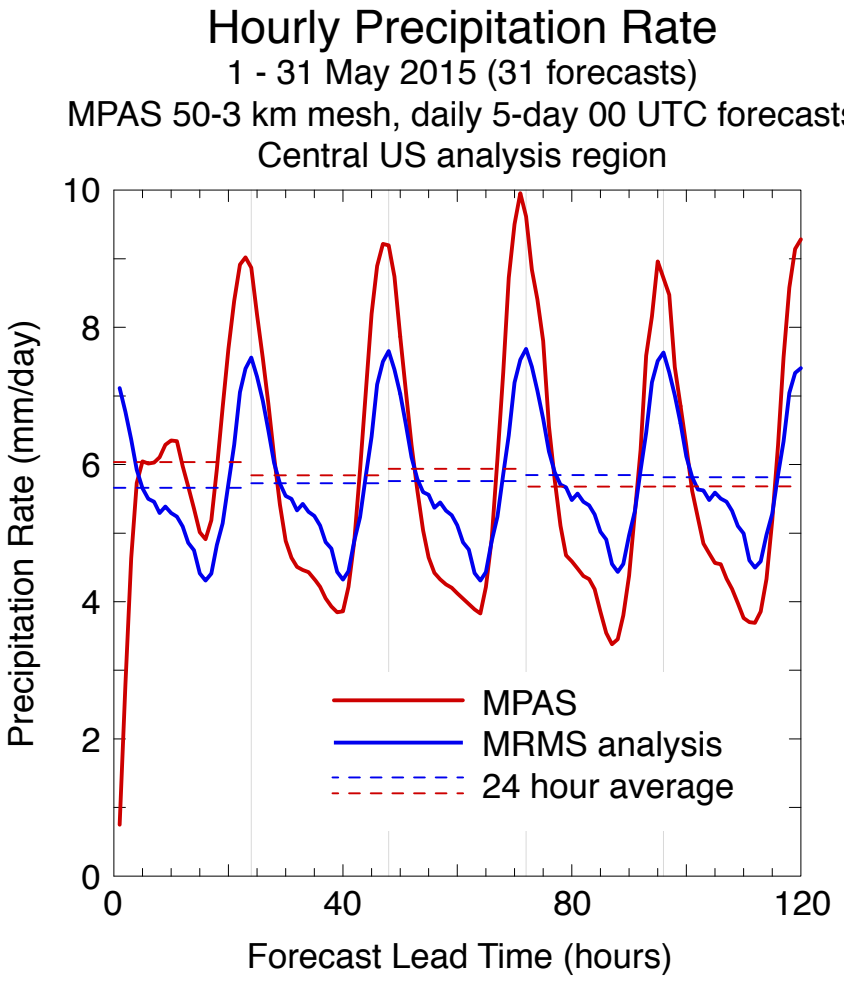

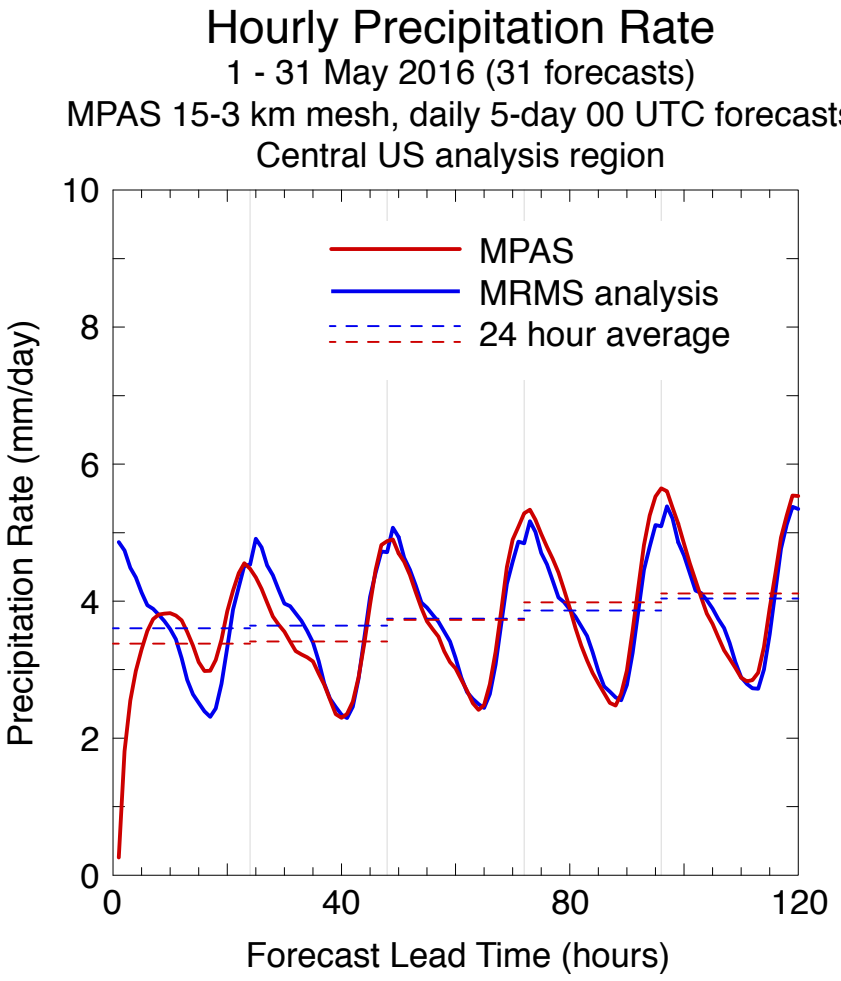

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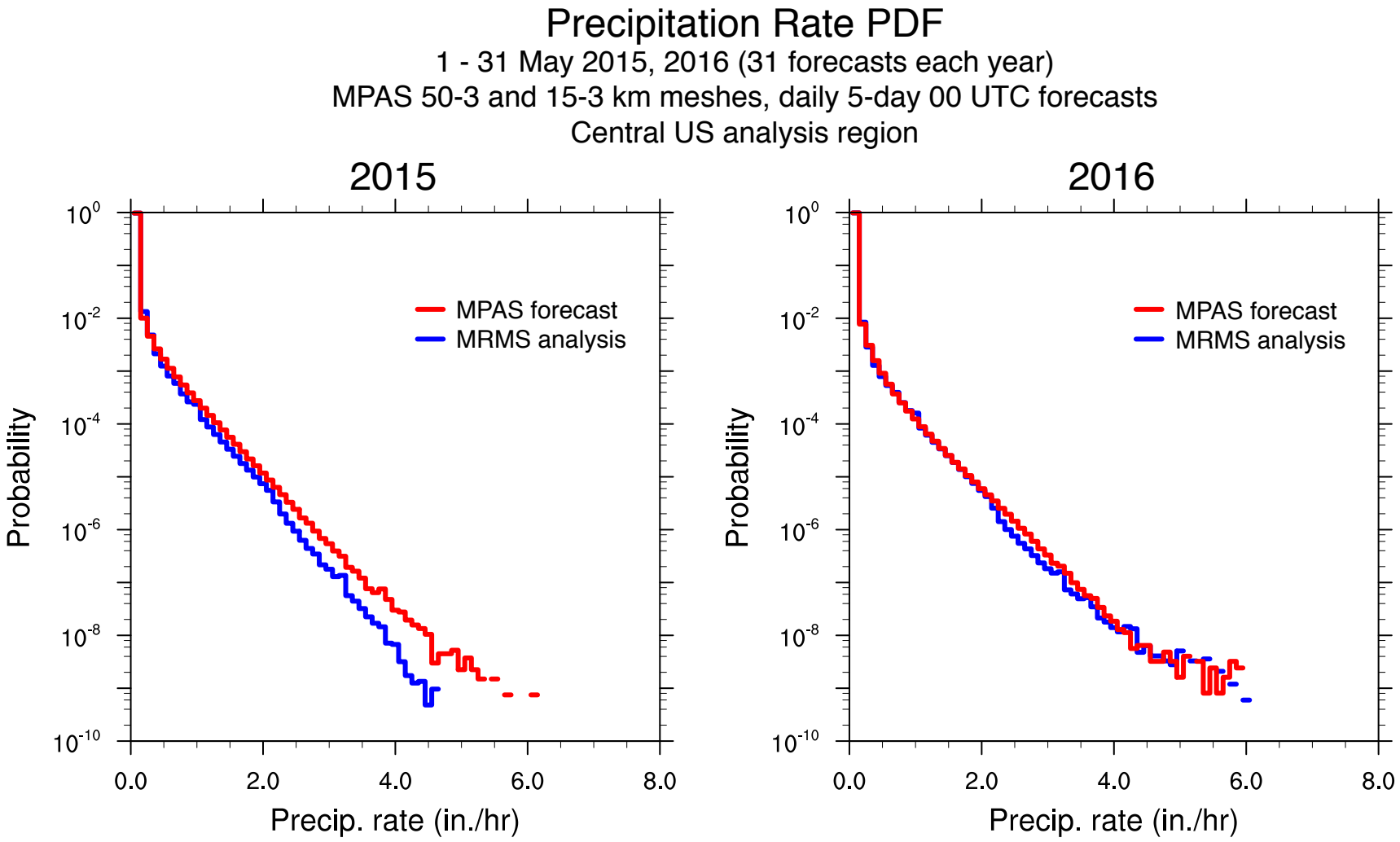
Hazardous Weather Testbed
Spring Experiment 2015, 2016
Forecasts Results from MPAS



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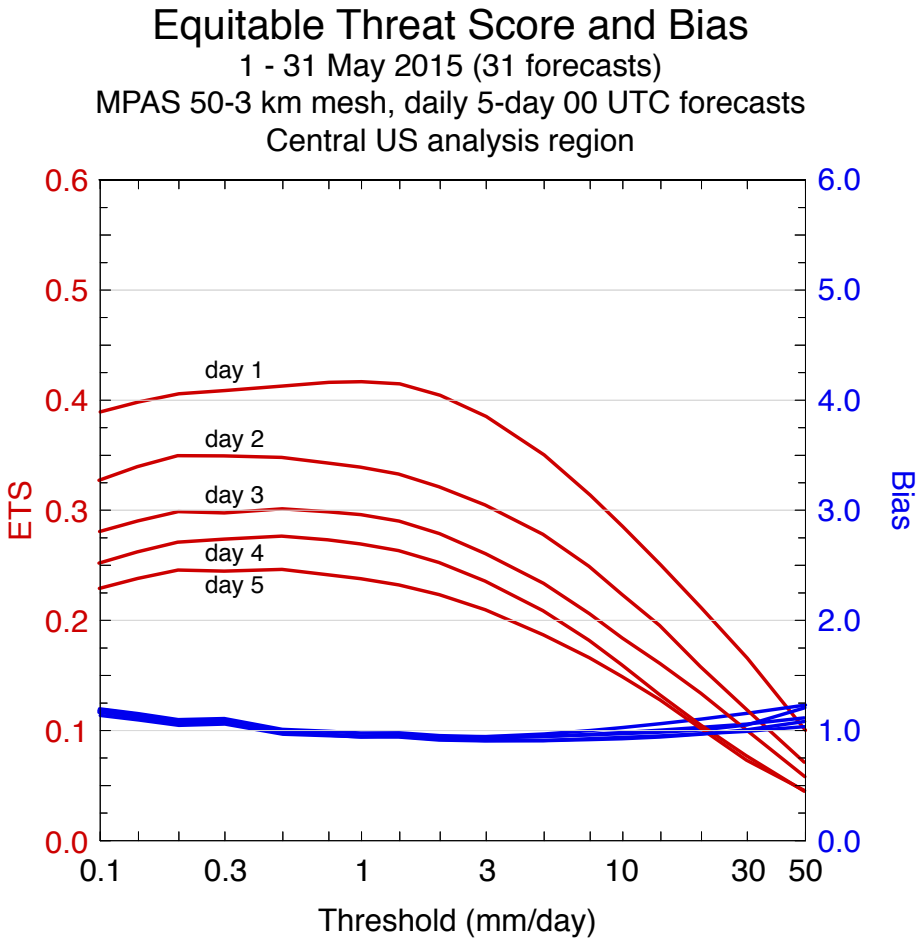
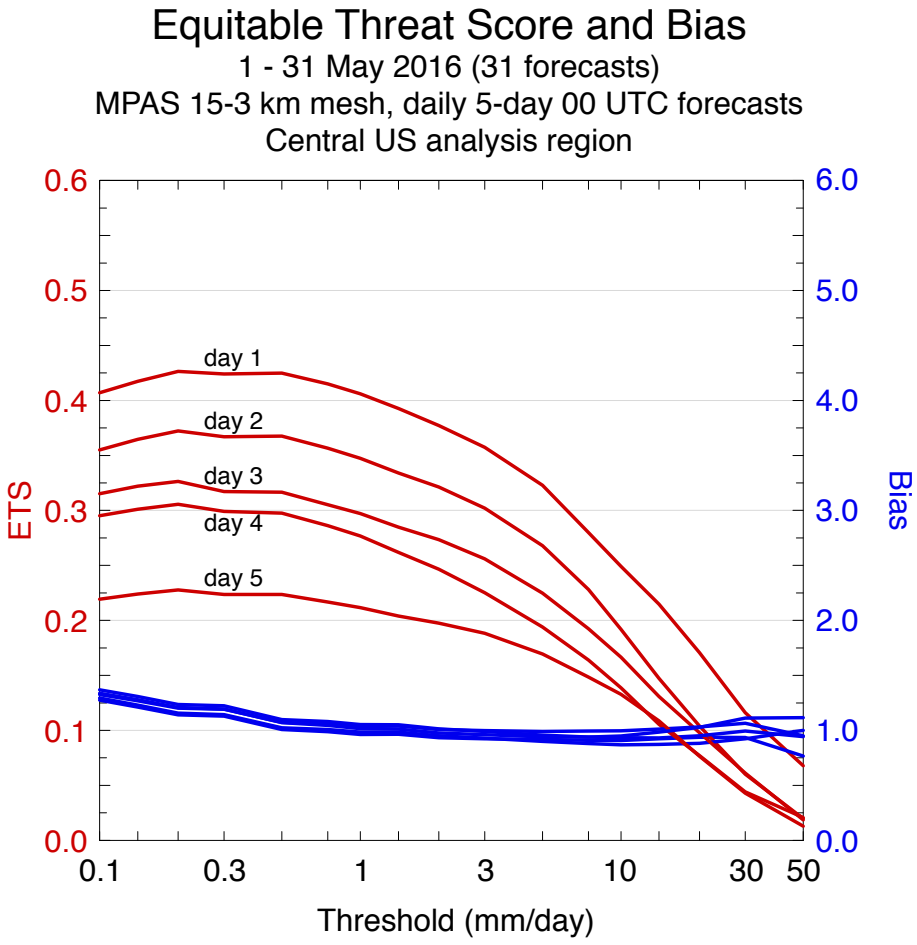
Hazardous Weather Testbed
Spring Experiment 2015, 2016
Forecasts Results from MPAS



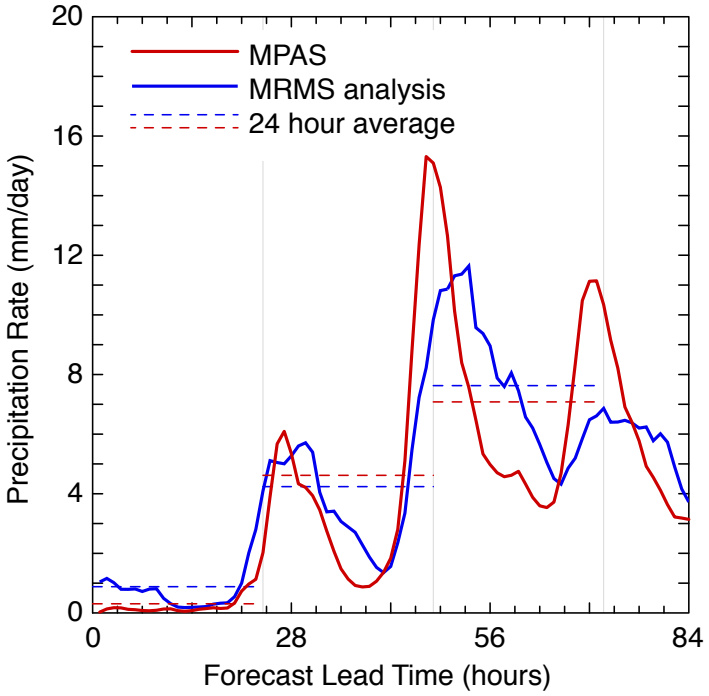


MPAS
Model for Prediction Across Scales

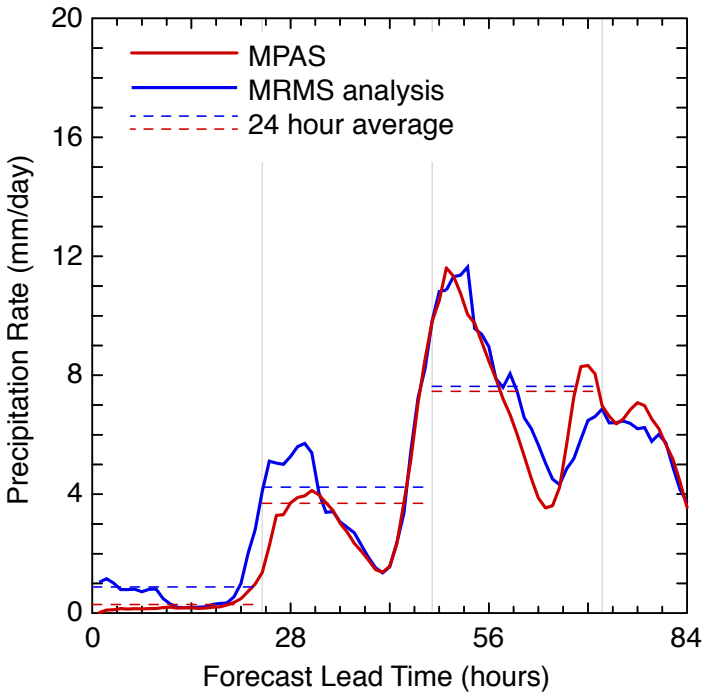
Hazardous Weather Testbed
Spring Experiment 2015, 2016
Forecasts Results from MPAS

Comparison of 2015 and 2016 Configurations
3 May 2015 Test Case

WSM6



Thompson

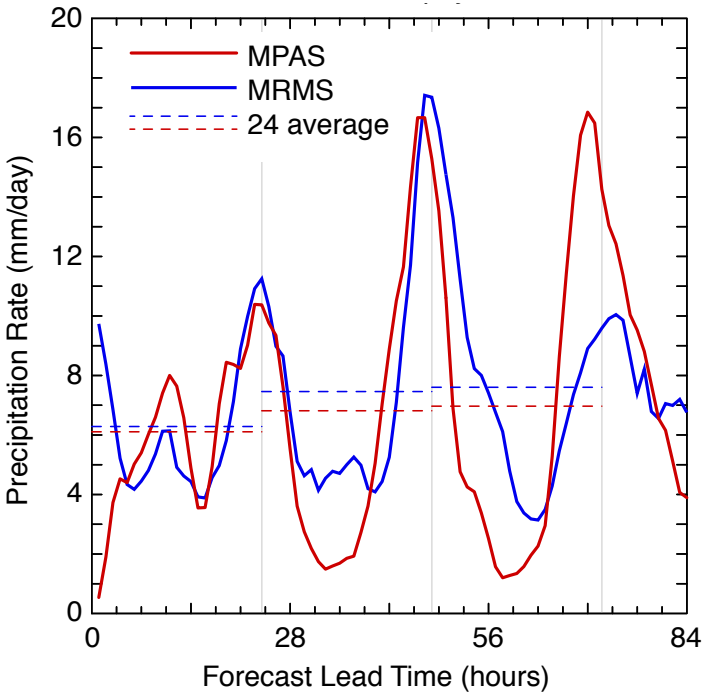


MPAS
Model for Prediction Across Scales

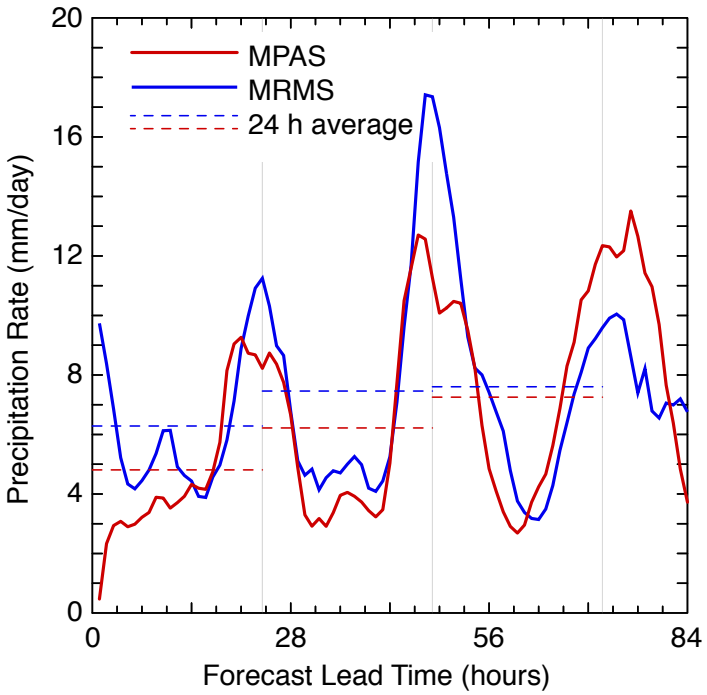
Hazardous Weather Testbed
Spring Experiment 2015, 2016
Forecasts Results from MPAS

Comparison of 2015 and 2016 Configurations
27 May 2015 Test Case

WSM6



Thompson



MPAS
Model for Prediction Across Scales

Hazardous Weather Testbed Spring Experiment 2015, 2016
Forecasts Results from MPAS

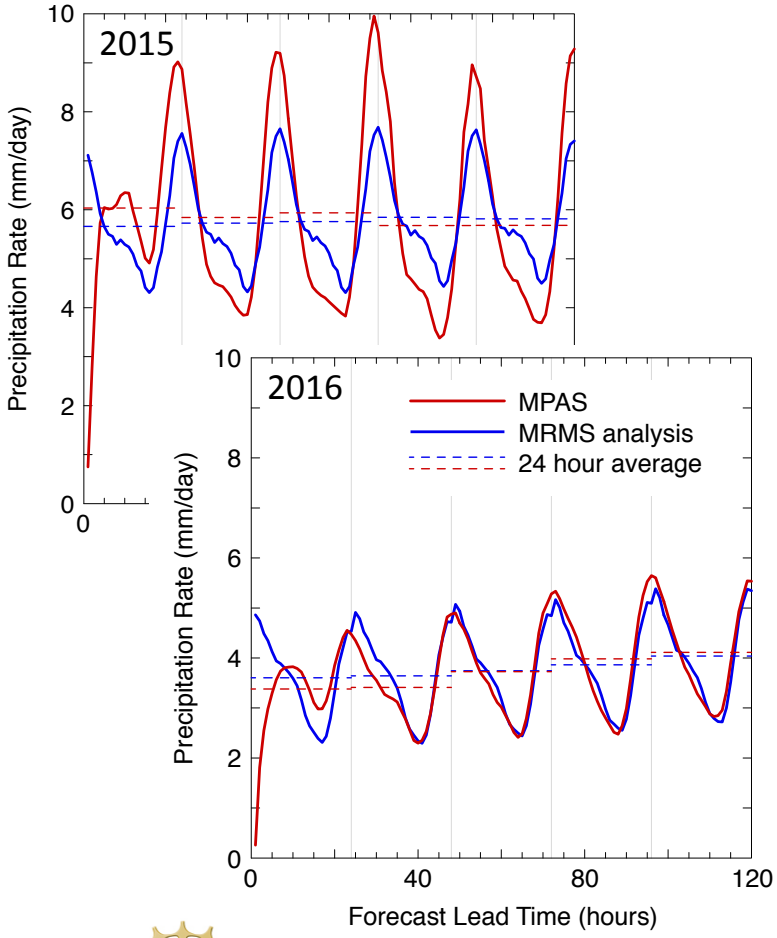
Summary

Convective scale forecasts

- Preliminary HWT MPAS forecasts may contain some extended-range convective guidance.
- Change from WSM6 (2015) to Thompson (2016) microphysics dramatically improved diurnal precipitation response over the central US.

Next Steps

- Further analysis of biases.
- Comparison of MPAS to 3 km CONUS ARW – benefit of the global configuration?
- Continue to evolve physics towards the HRRR suite.
- Moist high-resolution initialization to ameliorate precipitation spin-up for 2017 Spring Experiment.
- Global biases also need to be addressed.



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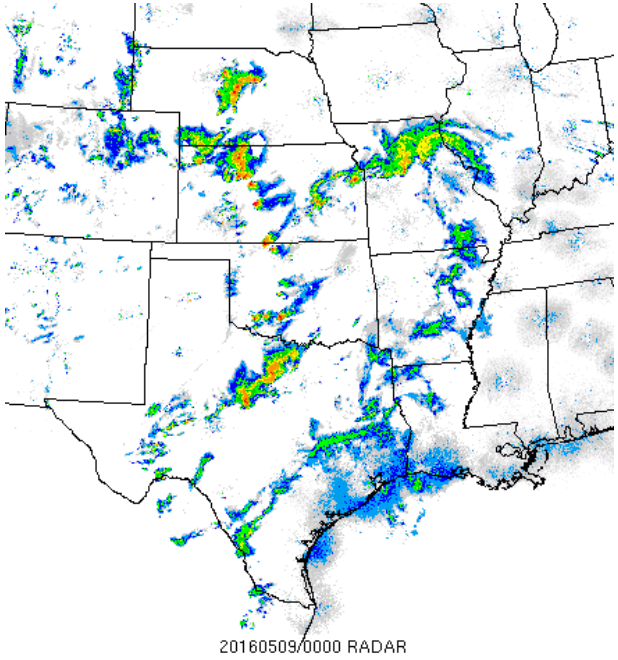
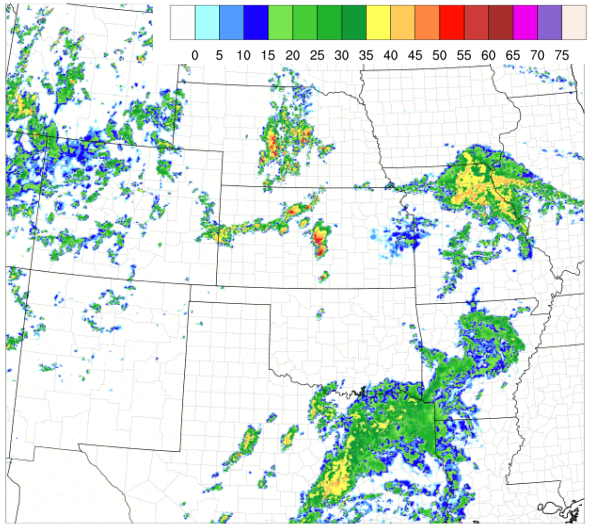
NOAA/SPC analysis, 00 UTC 9 May 2016

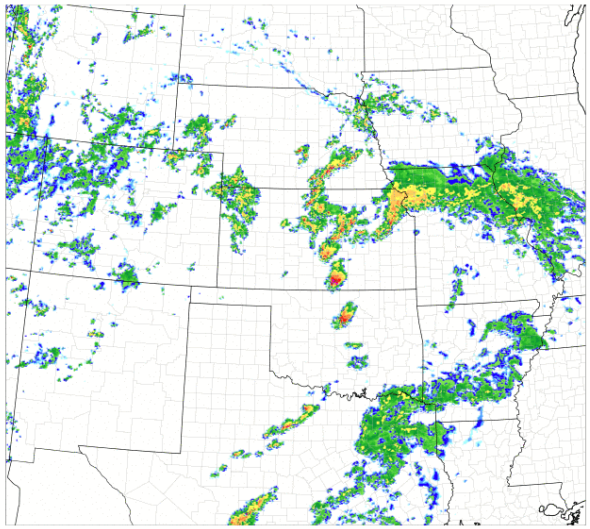


MPAS 1 km AGL Reflectivity

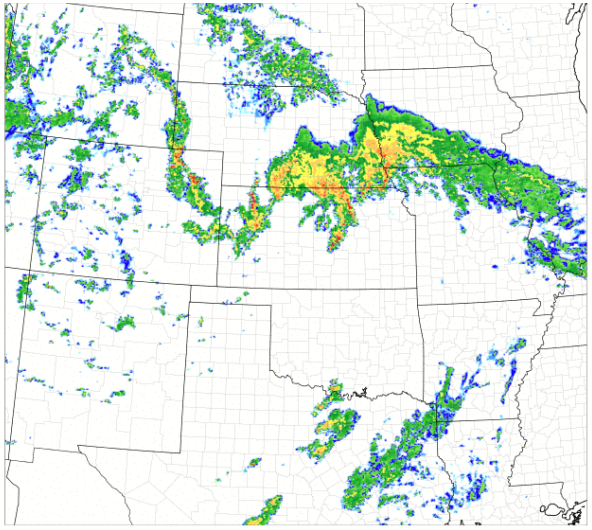
MPAS 24h forecast



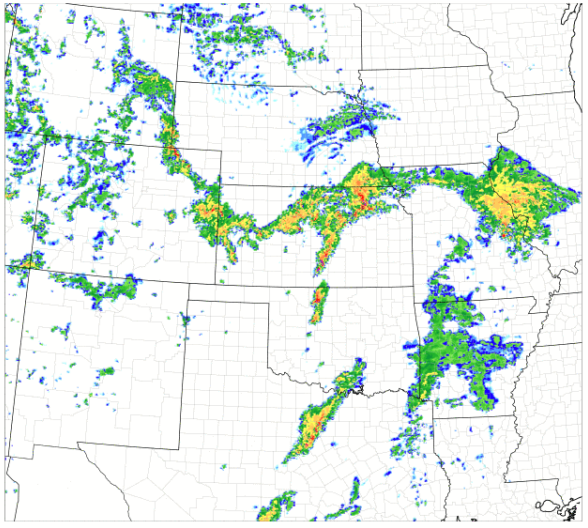
MPAS 48h forecast



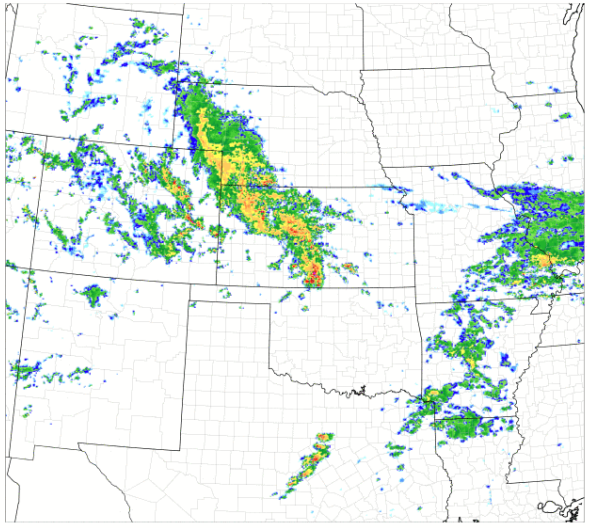
MPAS 72h forecast



MPAS 96h forecast



MPAS 120h forecast



MPAS
Model for Prediction Across Scales

MPAS Nonhydrostatic Atmospheric Solver

Fully Compressible Nonhydrostatic Equations

- Prognostic equations for coupled variables.
- Generalized height coordinate.
- Horizontally vector invariant eqn set.
- Continuity equation for dry air mass.
- Thermodynamic equation for coupled potential temperature.

Time integration as in Advanced Research WRF

- Split-explicit Runge-Kutta (3rd order)

Full complement of atmospheric-model physics

MPAS is based on unstructured centroidal Voronoi (hexagonal) meshes using C-grid staggering and selective grid refinement.