Short-term Probabilistic Forecasts of Multi-hazard Events Using a Prototype Warn-on-Forecast System

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WARN on FORECAST

Increasing lead times for hazardous weather warnings

Motivation

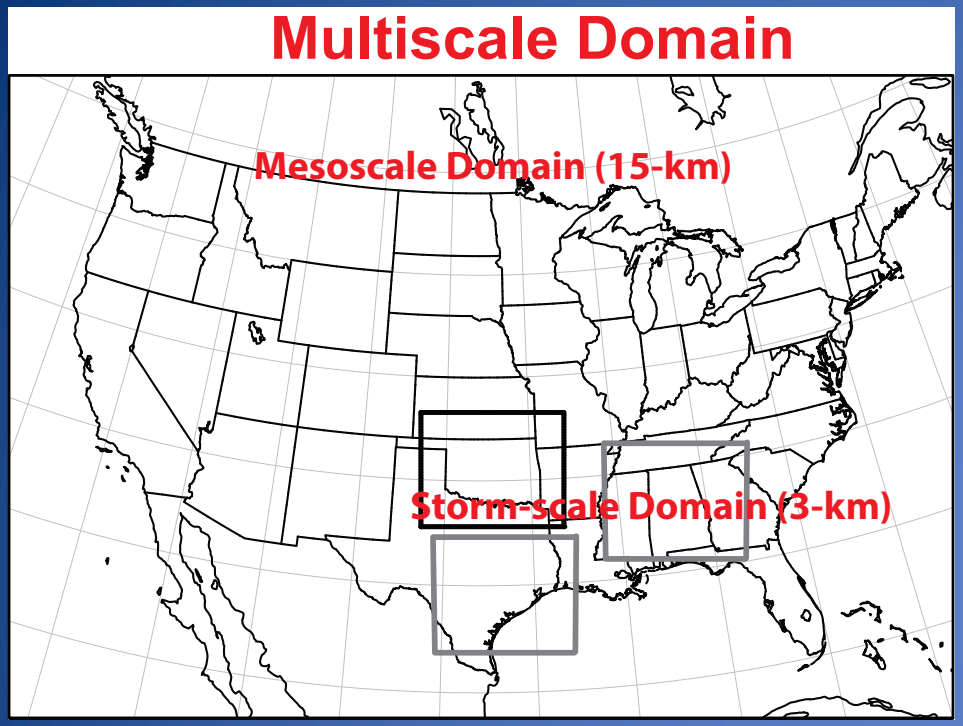
NOAA Warn-on-Forecast (WoF) research project

- Forecasters use probabilistic ensemble guidance to increase warning lead times of severe and hazardous convective weather
- Severe weather is particularly dangerous when there are multiple threats, with perhaps the most deadly combination involving both tornadoes and flash floods
- A key component of WoF is the development of continuous rapid-update storm-scale ensemble system for a very short-range (0-1 h) probabilistic forecasts

Why Flood/Flash Flood Event?

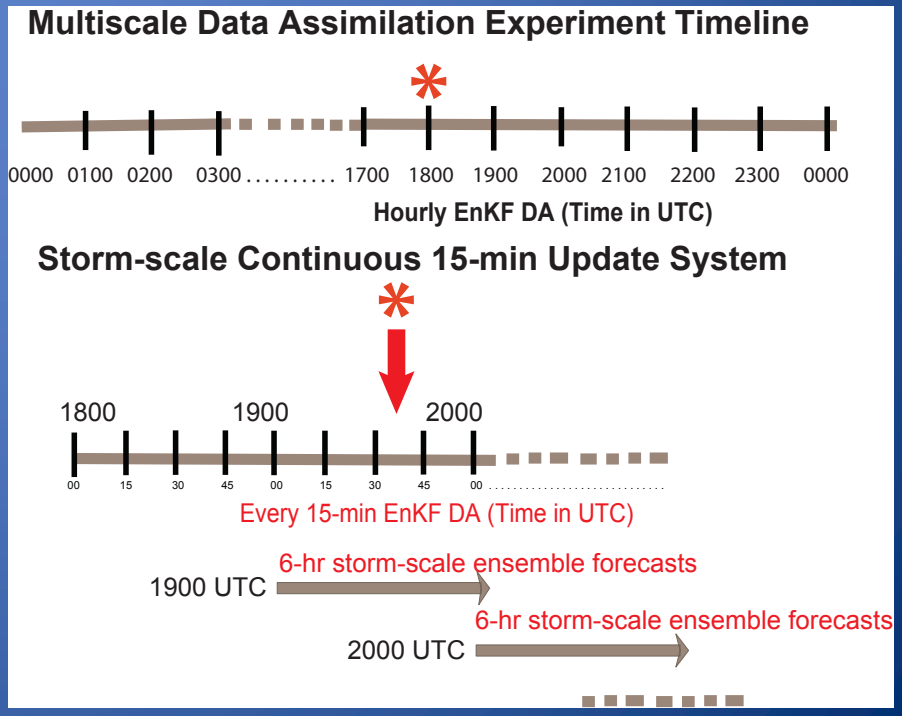
- Floods, especially flash floods, cause more fatalities in USA each year than tornadoes or hurricanes
- Significant property losses due to flash floods
  - Highest percentage of federal aid
- Increase in forecast lead time will help
  - Current warnings often < 1 h
- To increase flash floods forecast lead time, it is essential to drive the hydrologic models with accurate storm-scale precipitation forecasts

A Prototype Warn-on-Forecast System



Mesoscale Data assimilation

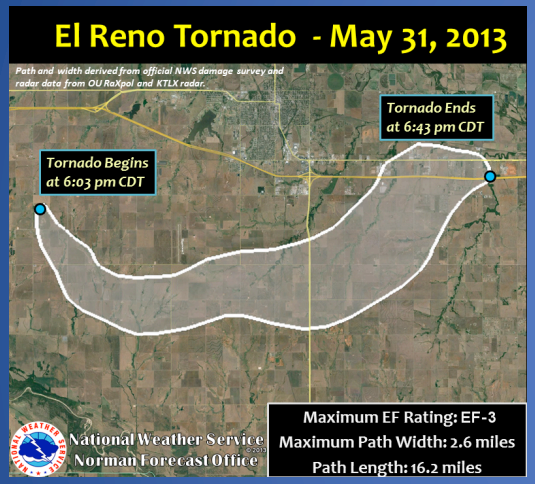
- WRF-ARW
- Data Assimilation Research Testbed (DART)
- Multiphysics ensemble
- IC/BC from Global Ensemble Forecast System
- Parent/nested grids run simultaneously in a 1-way nest setup
- Assimilate *Conventional Obs.* every 1 hour



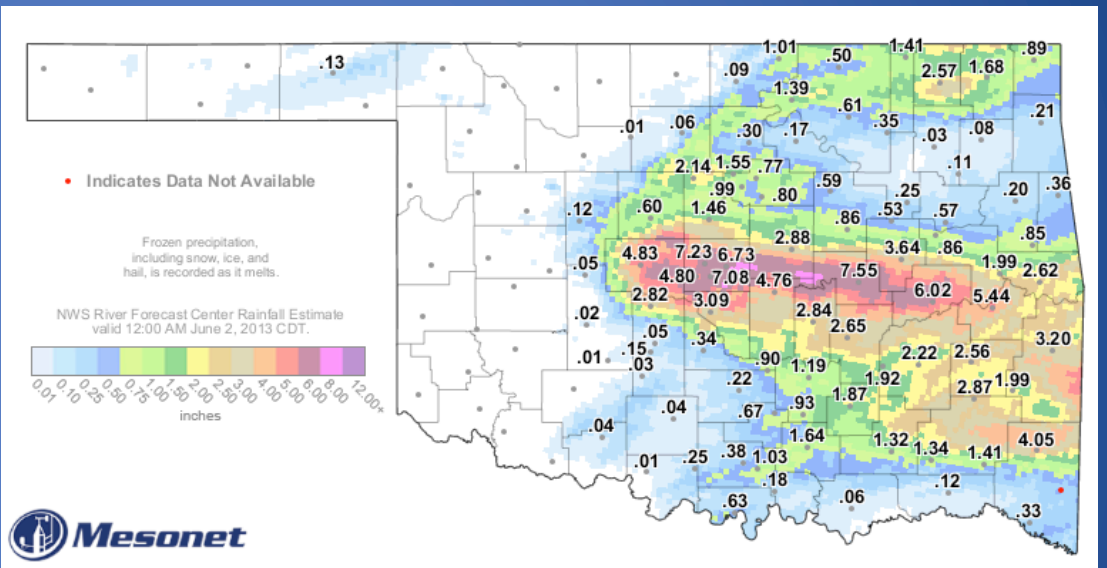
Storm-scale Data assimilation

- Storm-scale DA starts after storm initiation in the nested 3-km domain
- Radar reflectivity, radial velocity, mesonet and "conventional" observations
- Continuous assimilation every 15 mins

The 31 May – 1 June 2013 Tornado and Flash Flood Event over Central Oklahoma



- EF-3 Tornado
- Duration: 41 mins (2303 – 2343 UTC)
- 8 fatalities



- Flash flooding in Oklahoma City metro area
- First flooding report at 0100 UTC
- 13 fatalities

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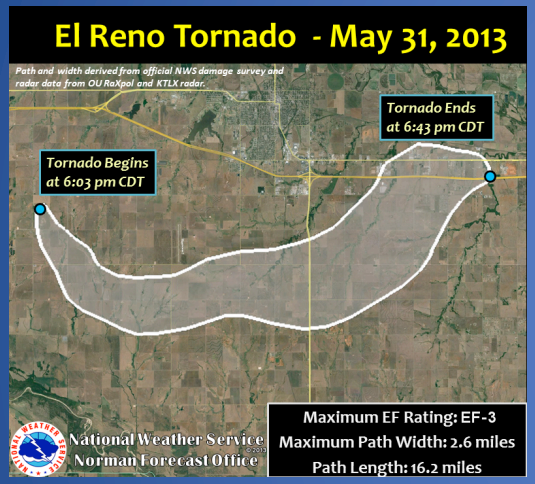

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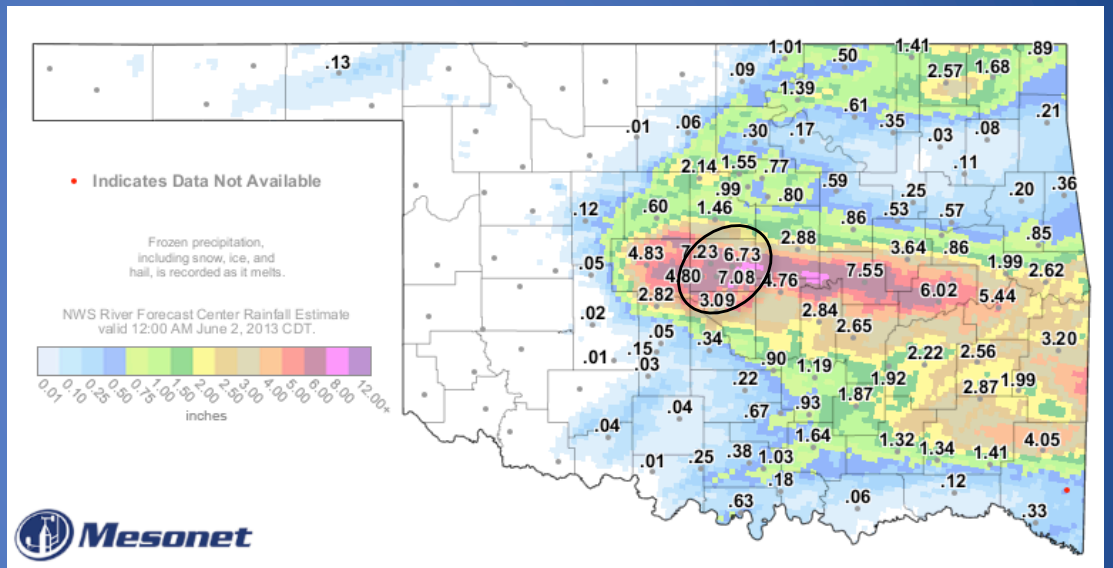

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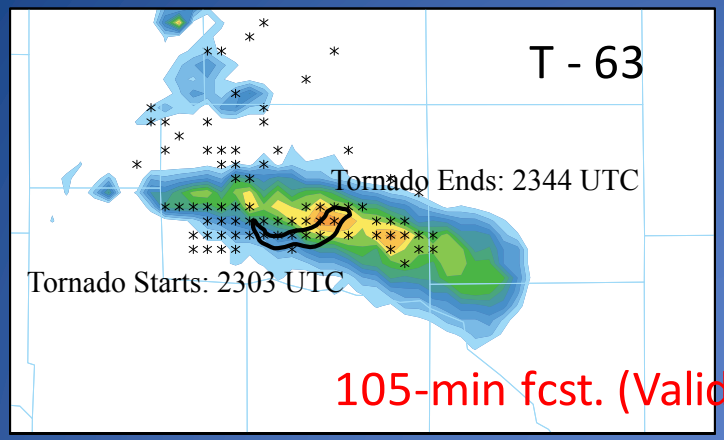
Probabilistic Forecasts of Hazards Using Continuous-Update-Cycle Storm-scale Ensemble

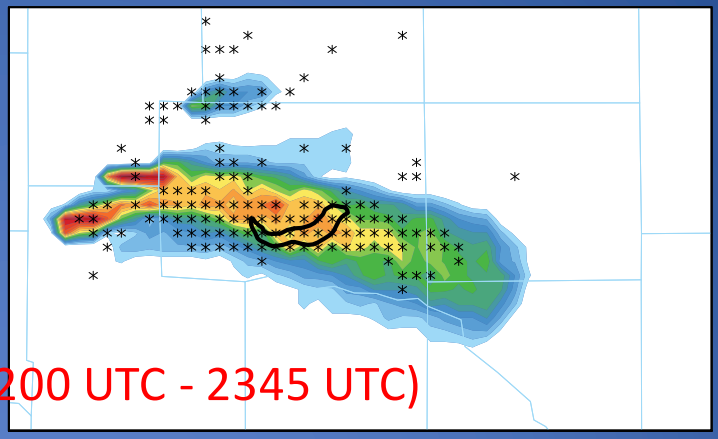
- Probabilistic forecasts of
  - Low level vorticity and mid level updraft helicity
  - Quantitative Precipitation Forecasts (QPF) and Probabilistic QPF of latter heavy rainfall
- Longer forecast lead times: 0-3 h
- 3-6 h (any skill?)

Rotation Track Forecast for El Reno Tornadic Supercell

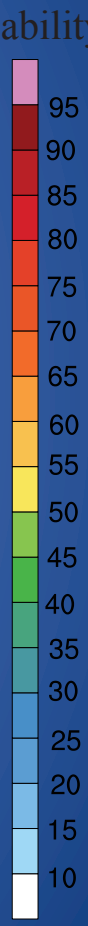
Vorticity > 0.003 s^{-1} at 1 km AGL



2-5 km Updraft Helicity > 100 $m^2 s^2$



105-min fcst. (Valid 2200 UTC - 2345 UTC)



Black dots are radar derived (WDSS-II) rotation locations

Black line is NWS damage path

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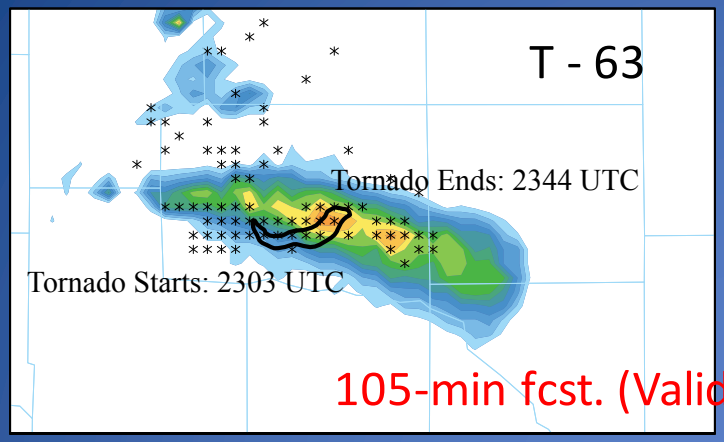

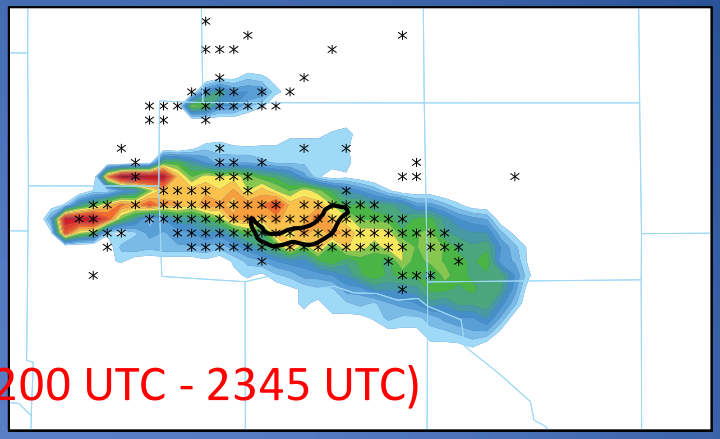

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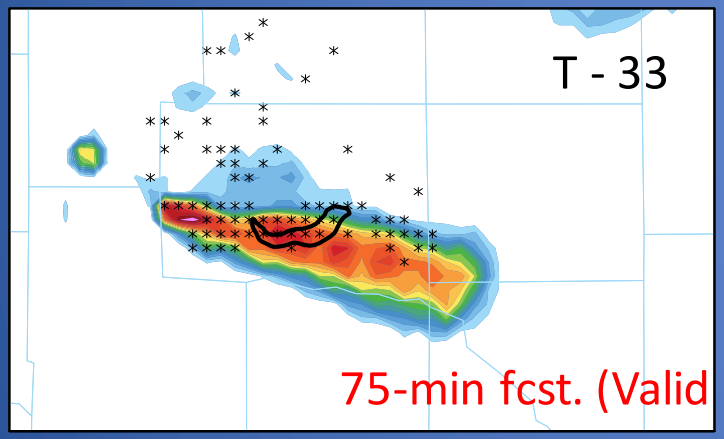
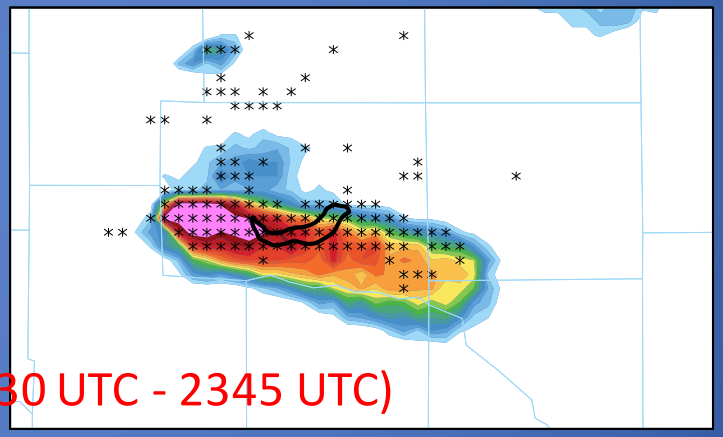
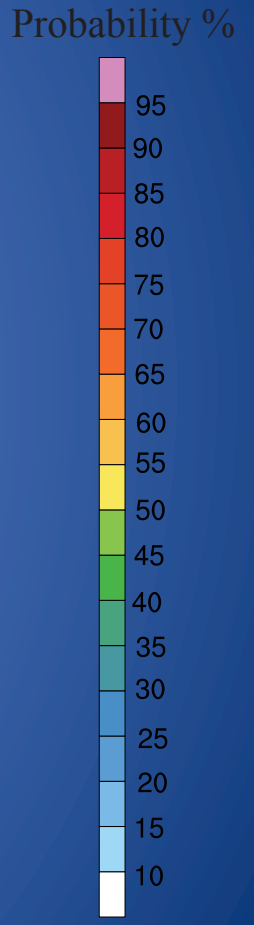




75-min fcst. (Valid 2230 UTC - 2345 UTC)



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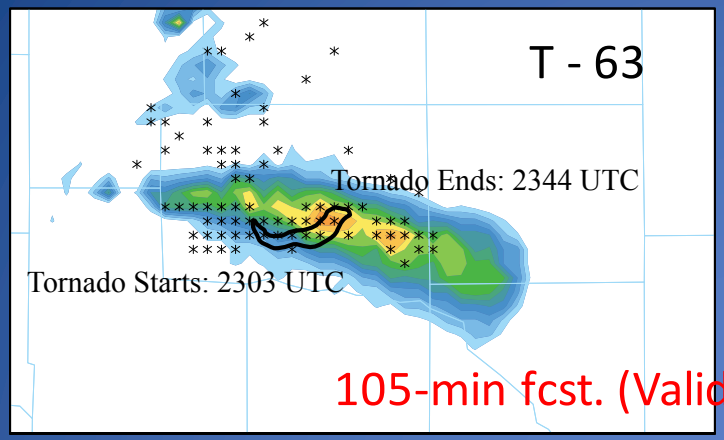
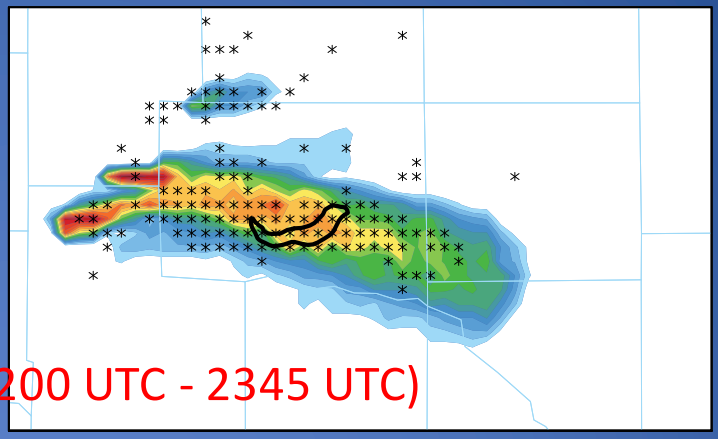
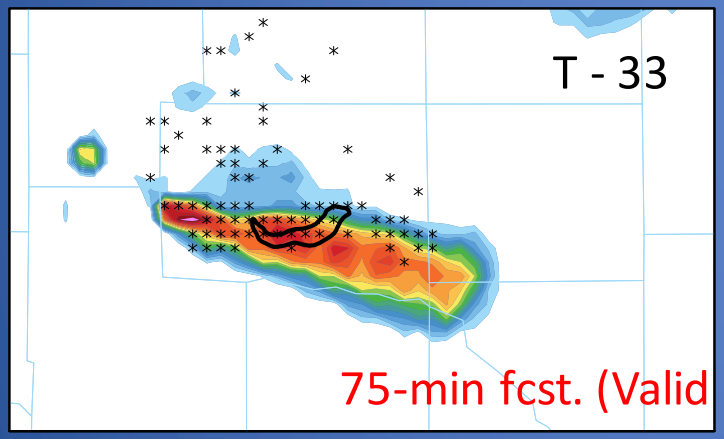
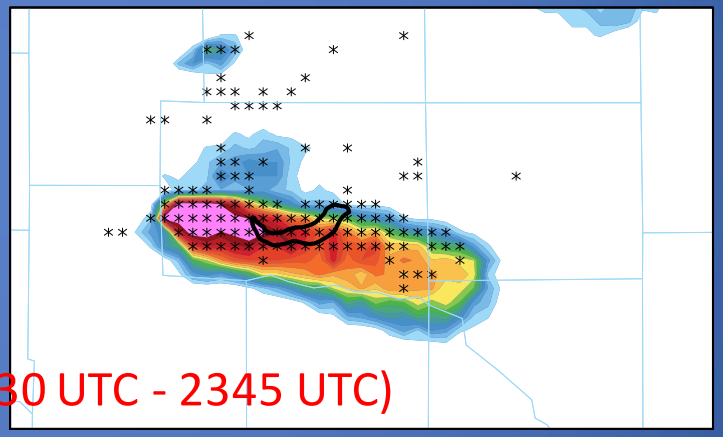


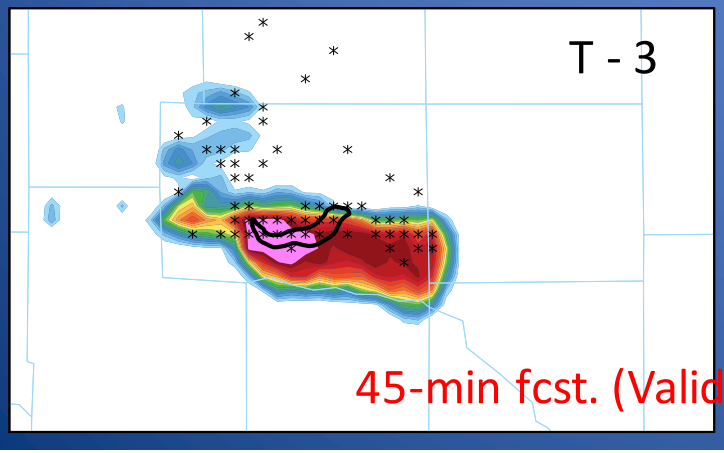


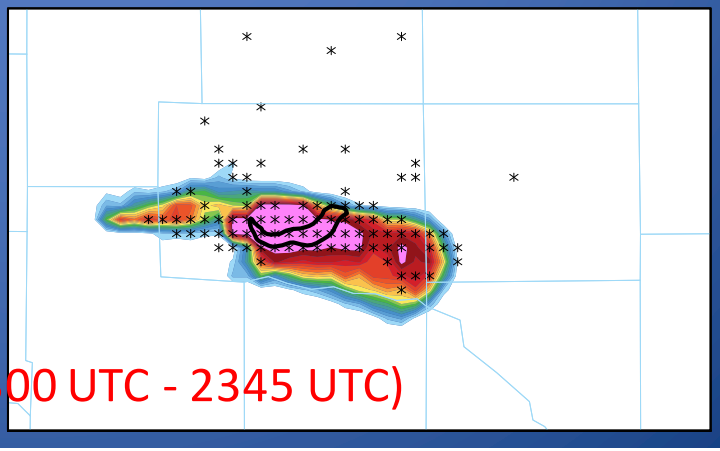
105-min fcst. (Valid 2200 UTC - 2345 UTC)



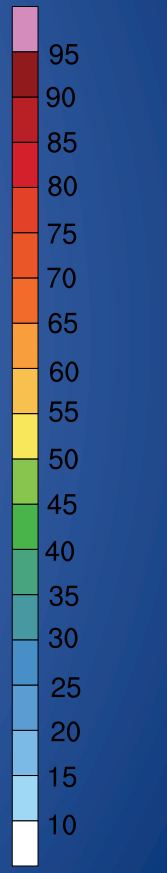


75-min fcst. (Valid 2230 UTC - 2345 UTC)



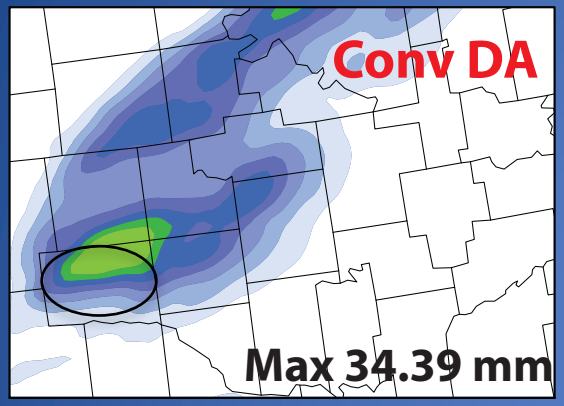


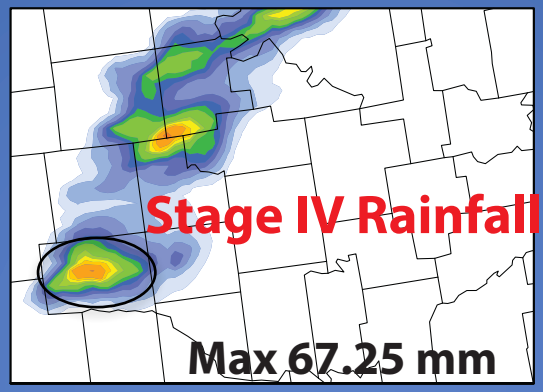
45-min fcst. (Valid 2300 UTC - 2345 UTC)

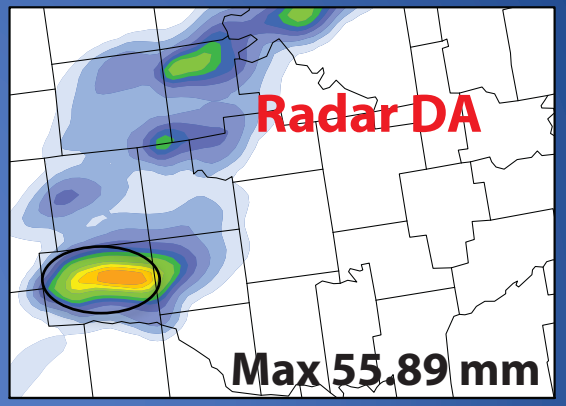


Quantitative Precipitation Forecast (QPF)
initialized 2 hours before the first flood report

1-h Rainfall Forecast (Valid 2300 - 0000 UTC)

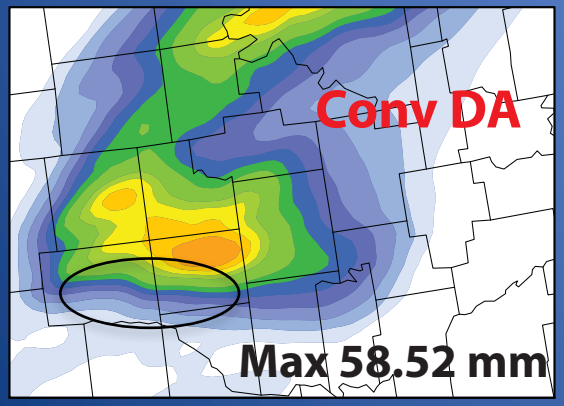


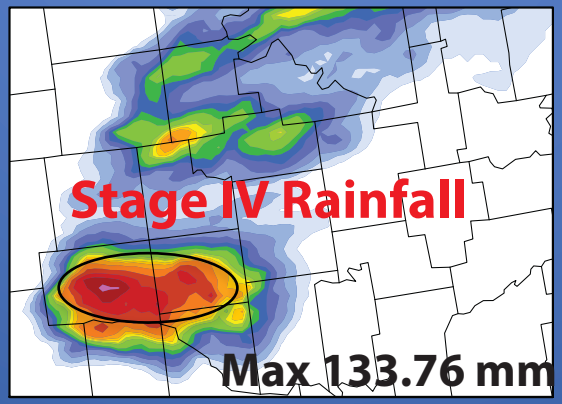


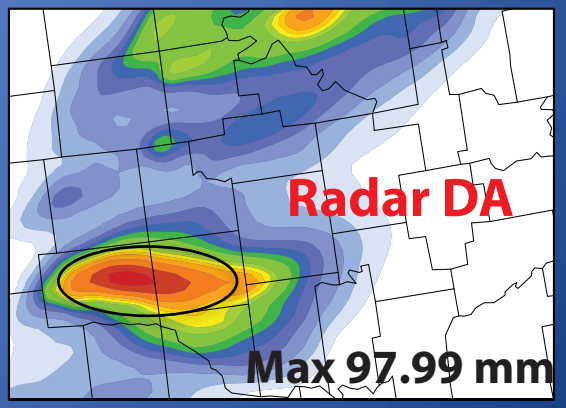


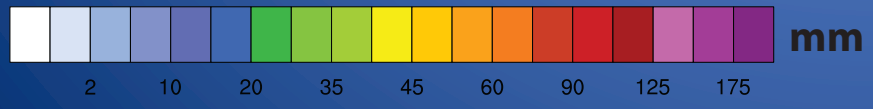
First flood report at 0100 UTC

3-h Rainfall Forecast (Valid 2300 - 0200 UTC)





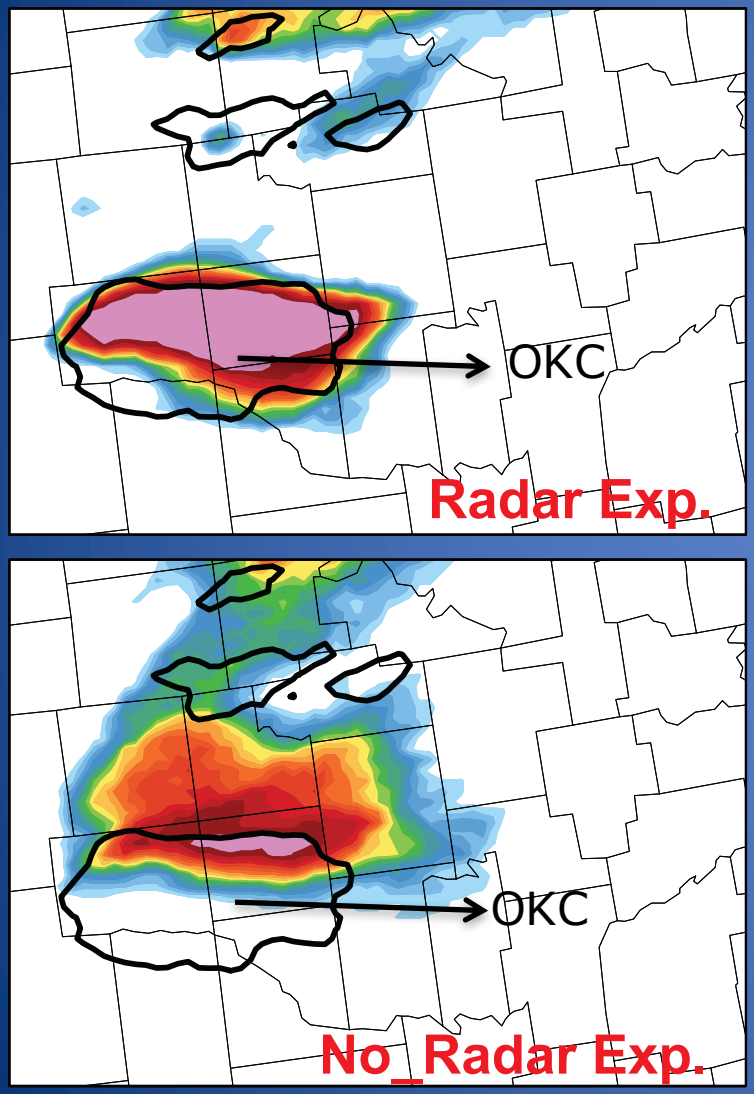




Radar DA better predicts the amount and areal coverage of QPF

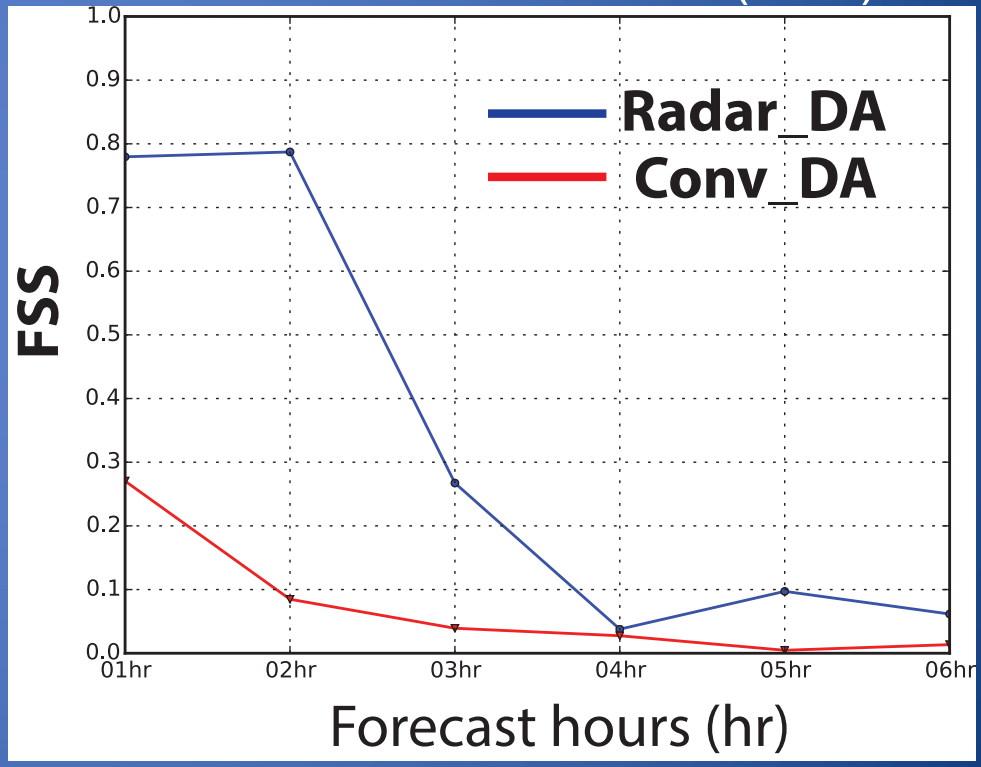
Probabilistic Quantitative Precipitation Forecast

Prob. of 0-3 h PQPF > 25 mm



Stage-IV 25 mm rainfall contour

Fractional Skill Score (FSS)



Higher FSS scores are better

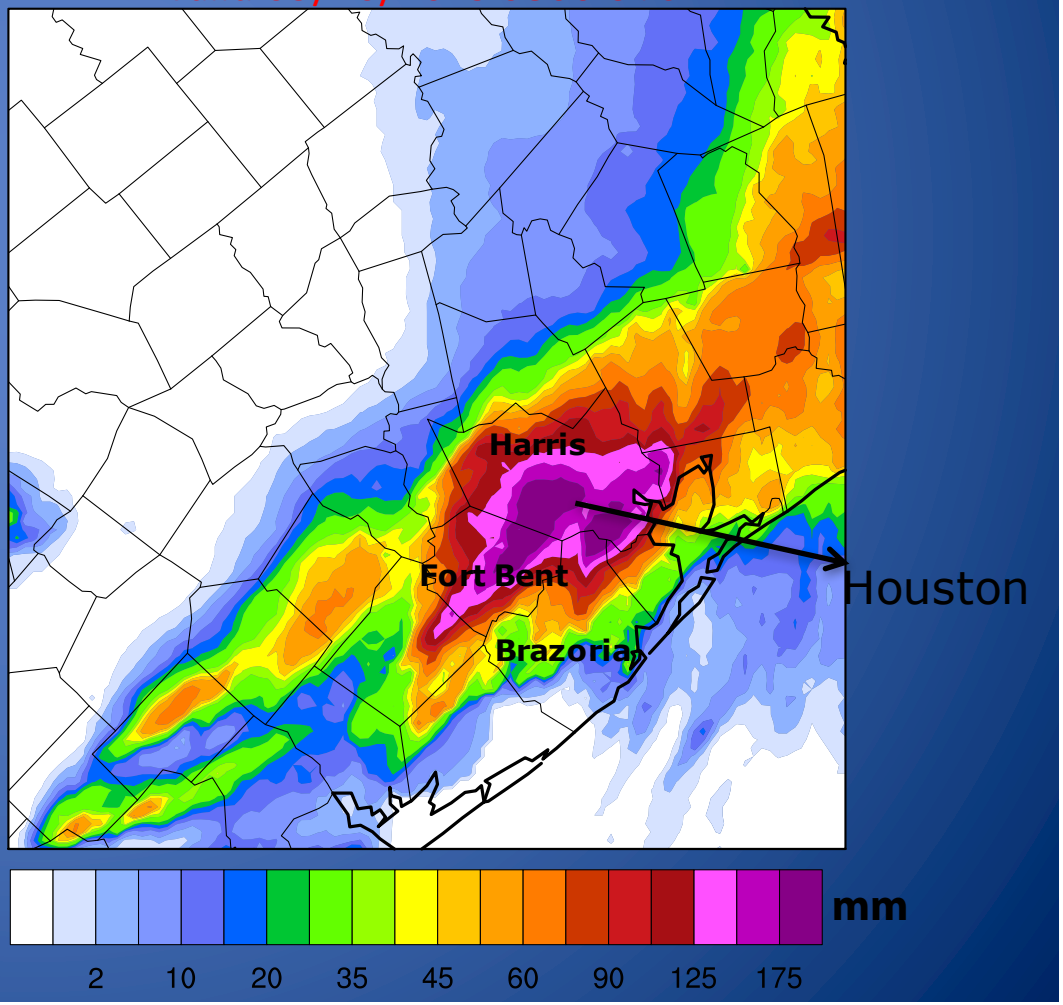
Yussouf, N., J. S. Kain, and A. J. Clark, 2016: Short-term Probabilistic Forecasts of the 31 May 2013 Oklahoma Tornado and Flash Flood Event Using a Continuous-Update-Cycle Storm-scale Ensemble System. *Wea. Forecasting*, in press.

Houston, TX Flash Flood on May 25-26, 2015

- Harris/Fort Bend/Brazoria county 5-11 inches of rainfall across the area
- 8 vehicle-related fatalities and more than 1000 stranded vehicles towed
- Hundreds of water rescues from stranded motorists
- More than 1000 structures impacted

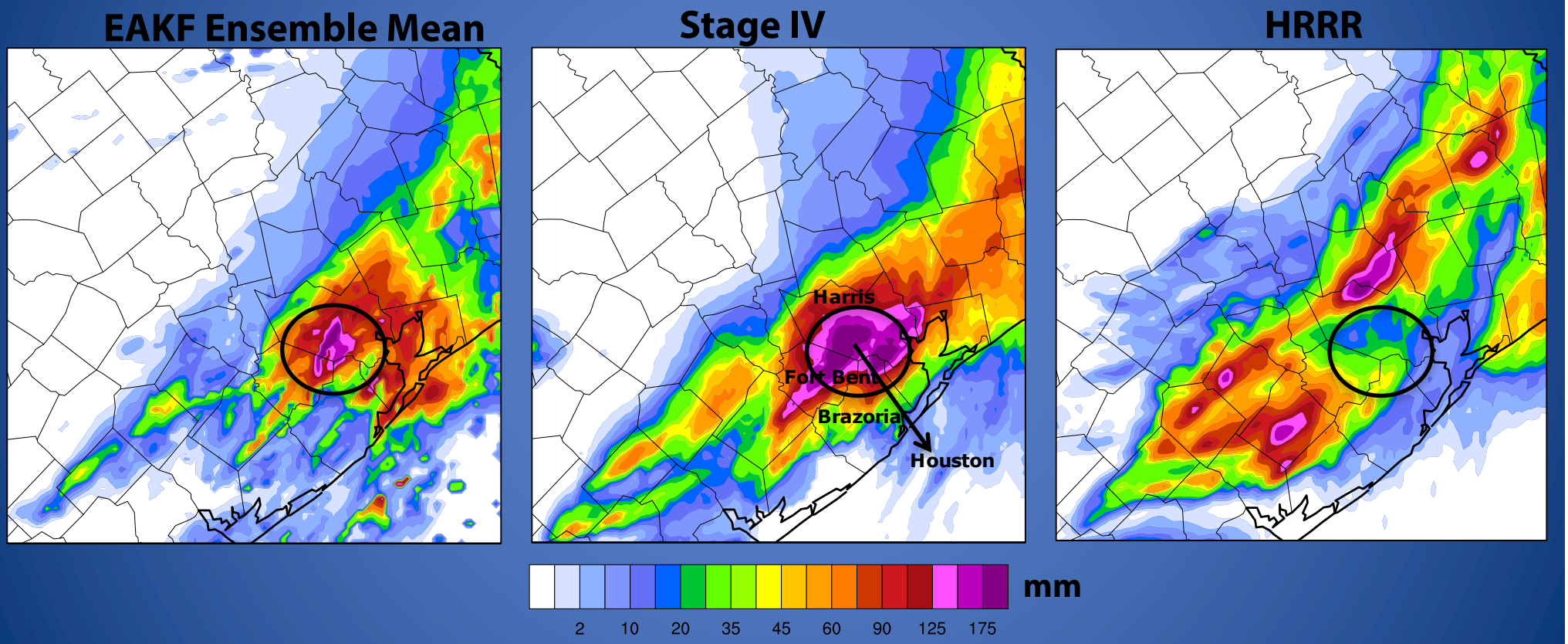
NCEP Stage IV 6-hr Rainfall

Valid 05/26/2015 0800 UTC



6-hr Precipitation Forecast

Valid 0800 UTC 26 May 2015



Summary

The continuous-update-cycle storm-scale EnKF ensemble (WoF) system can

- ✓ provide useful short-term heavy rainfall forecasts in terms of location (areal coverage) and amount
- ✓ provide probabilistic guidance of heavy rainfall events
- ✓ be utilized to increase probabilistic flash flood forecast lead time