

Plans for RUC, Rapid Refresh, High-Resolution Rapid Refresh (HRRR) (and probabilistic guidance)

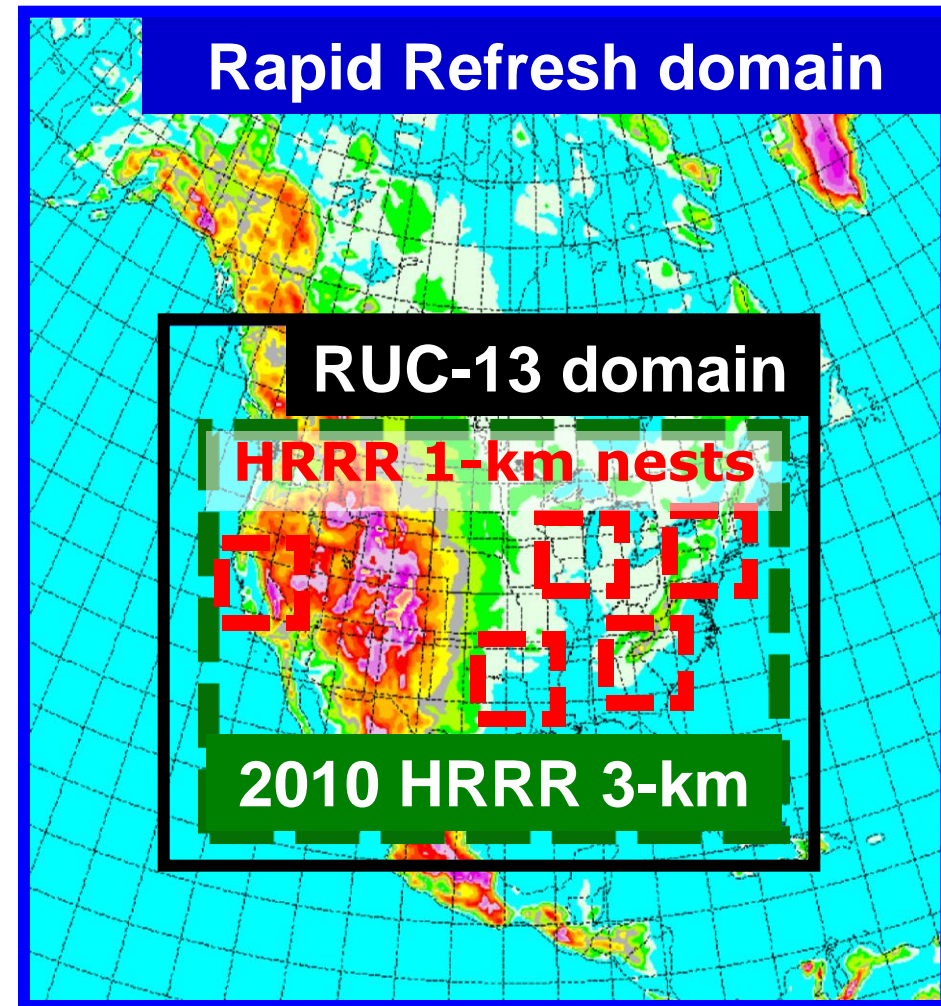
Stan Benjamin
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Tanya Smirnova
John Brown
Joe Olson

<http://rapidrefresh.noaa.gov>

<http://ruc.noaa.gov/hrrr>



Earth System Research Laboratory
SCIENCE, SERVICE & STEWARDSHIP



AMB Collaborations with DTC and HWT (also NCAR, SPC, NSSL, CAPS)

DTC / NCAR

- WRF core test comparison, vertical level tests, etc.
- GSI code management (SVN, community releases)
- Verification of HRRR forecasts for spring program
- WRF code sharing with NCAR

HWT / SPC / NSSL / CAPS

- Pre-implement evaluation of operational RUC upgrades
- AMB participation in Spring Programs, HRRR evaluation
- Work with SPC on convective probability forecasting
- HRRR support for VORTEX2, post-proc code from from NSSL
- Beginning shared work with NSSL on Warn on Forecast
- Collaborative work with CAPS on data assimilation for Nextgen

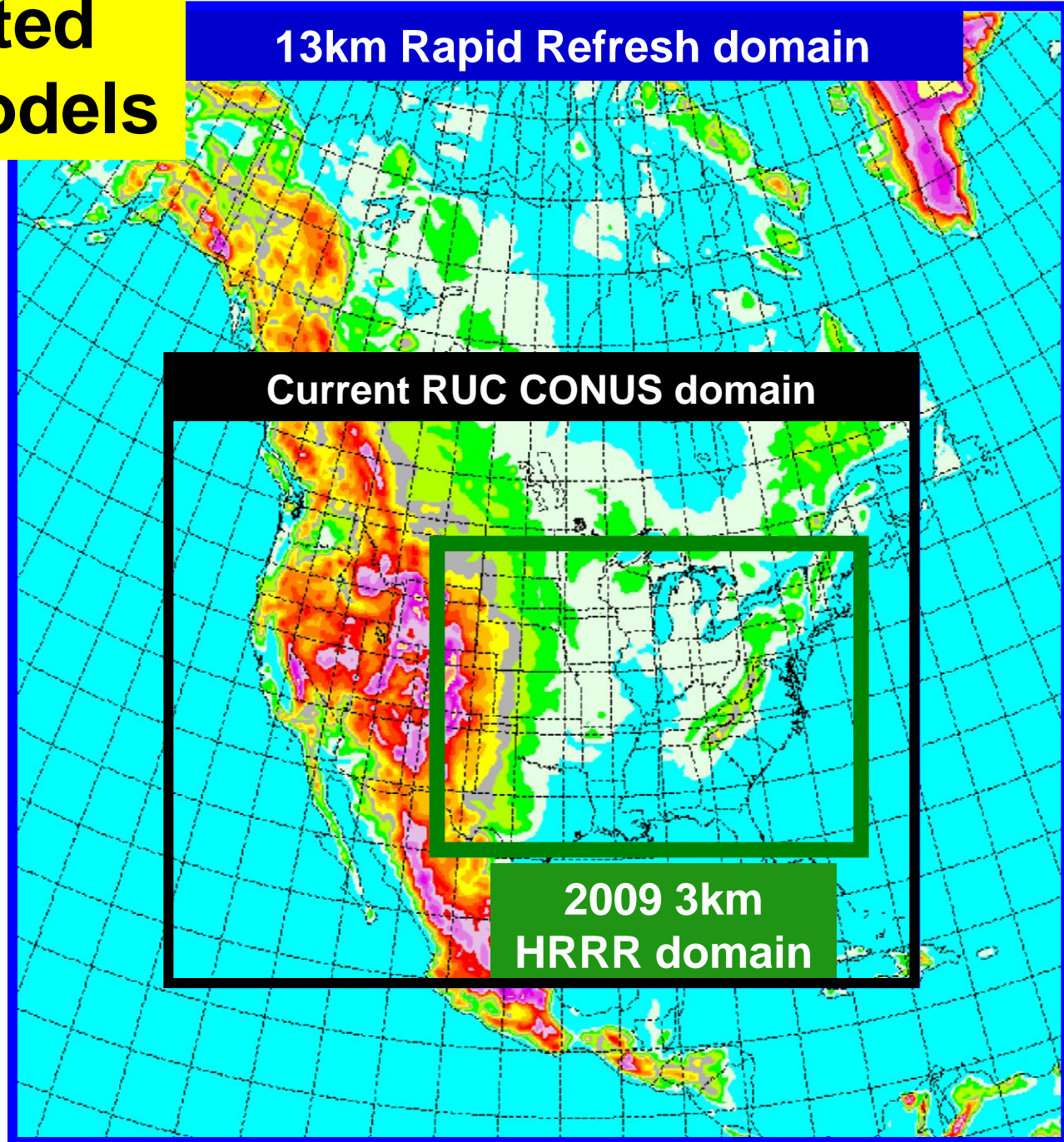
Hourly Updated NOAA NWP Models

13km Rapid Refresh domain

RUC – current oper
model - 13km

**Rapid Refresh
(RR)** – replace RUC at
NCEP in 2010 - WRF,
GSI w/ RUC-based
enhancements
- Goes to 6-member
ensemble in 2012-13

**HRRR - Hi-Res
Rapid Refresh**
-Experimental 3km

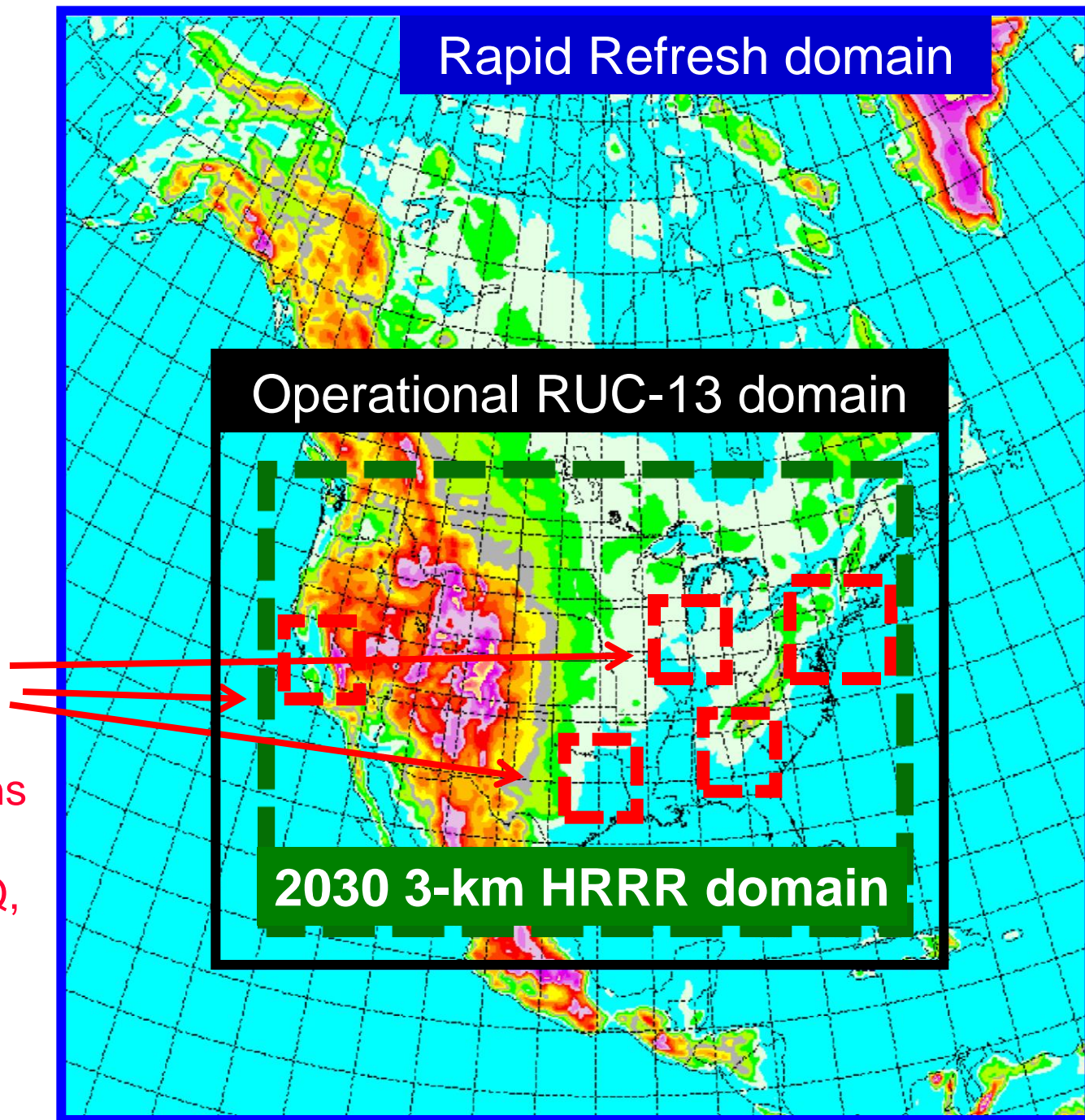


Rapid Refresh,
HRRR, +0.5-
1.0km HRRR
subnests

HRRR – 2010
demonstration for
aviation impact

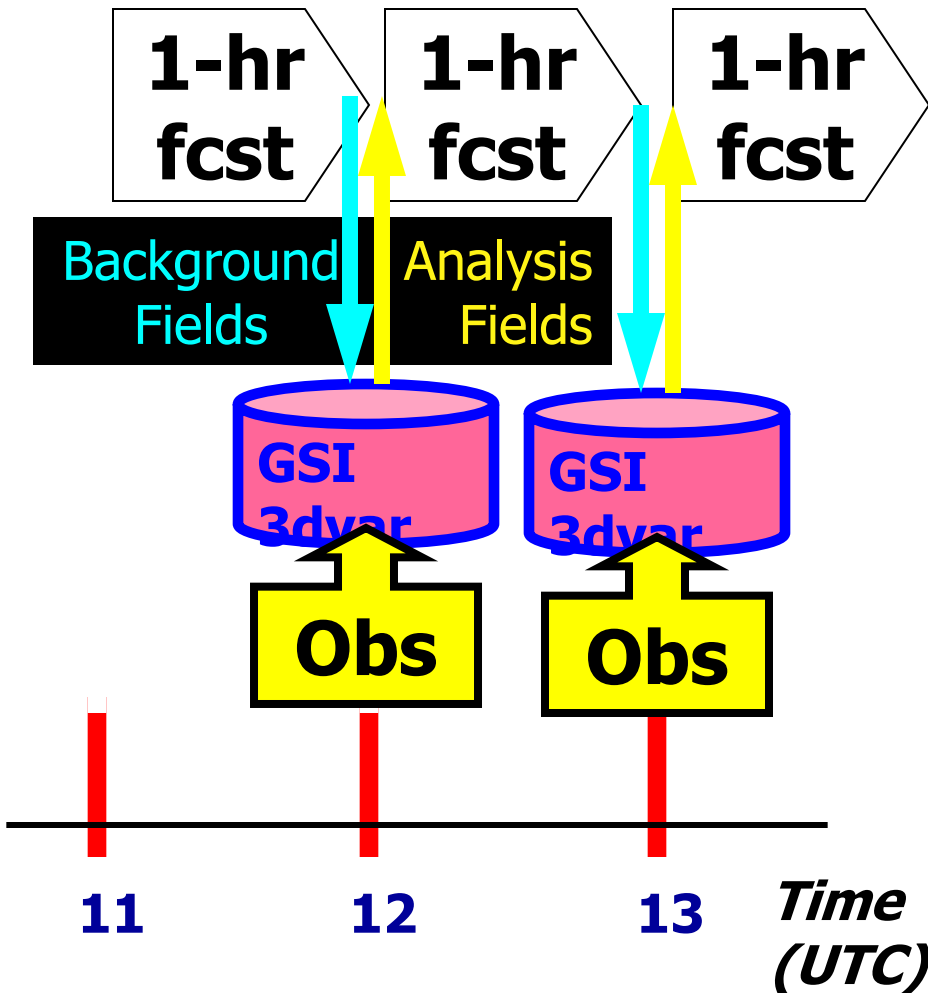
Planned HRRR
1-km subnests
(2-way boundary!)

RR/HRRR Applications
– aviation, severe wx,
renewable energy, AQ,
fire, hydro



RUC/Rapid Refresh Hourly Assimilation Cycle

Cycle hydrometeor, soil temp/moisture/snow plus atmosphere state variables



Hourly obs

Data Type	~Number
Rawinsonde (12h)	150
NOAA profilers	35
VAD winds	120-140
PBL – prof/RASS	~25
Aircraft (V,temp)	3500-10000
TAMDAR (V,T,RH)	200-3000
Surface/METAR	2000-2500
Buoy/ship	200-400
GOES cloud winds	4000-8000
GOES cloud-top pres	10 km res
GPS precip water	~300
Mesonet (temp, dpt)	~8000
Mesonet (wind)	~4000
METAR-cloud-vis-wx	~1800
AMSU-A/B/GOES radiances	
Radar reflectivity/ lightning	1km

Flow for RUC/RR hydrometeor assimilation

1h fcst
Qv, qc, qi

Sat cloud-top
Pres/temp/path

METAR cloud/visib
/current weather

Radar 3-d
reflectivity

Lightning

Analysis –
RUC-3dvar
or
GSI-3dvar

- Force interconsistency between ob types
- 3-d spatial mapping of Y/N/unknown (from obs) for cloud hydrometeors, precip hydrometeors

Modified
Qv, qc, qi

3-d latent heating from
radar + lightning (extendable to
sat-estim precip or growing
cumulus (“convective initiation”))

2-d convective
Inhibition field

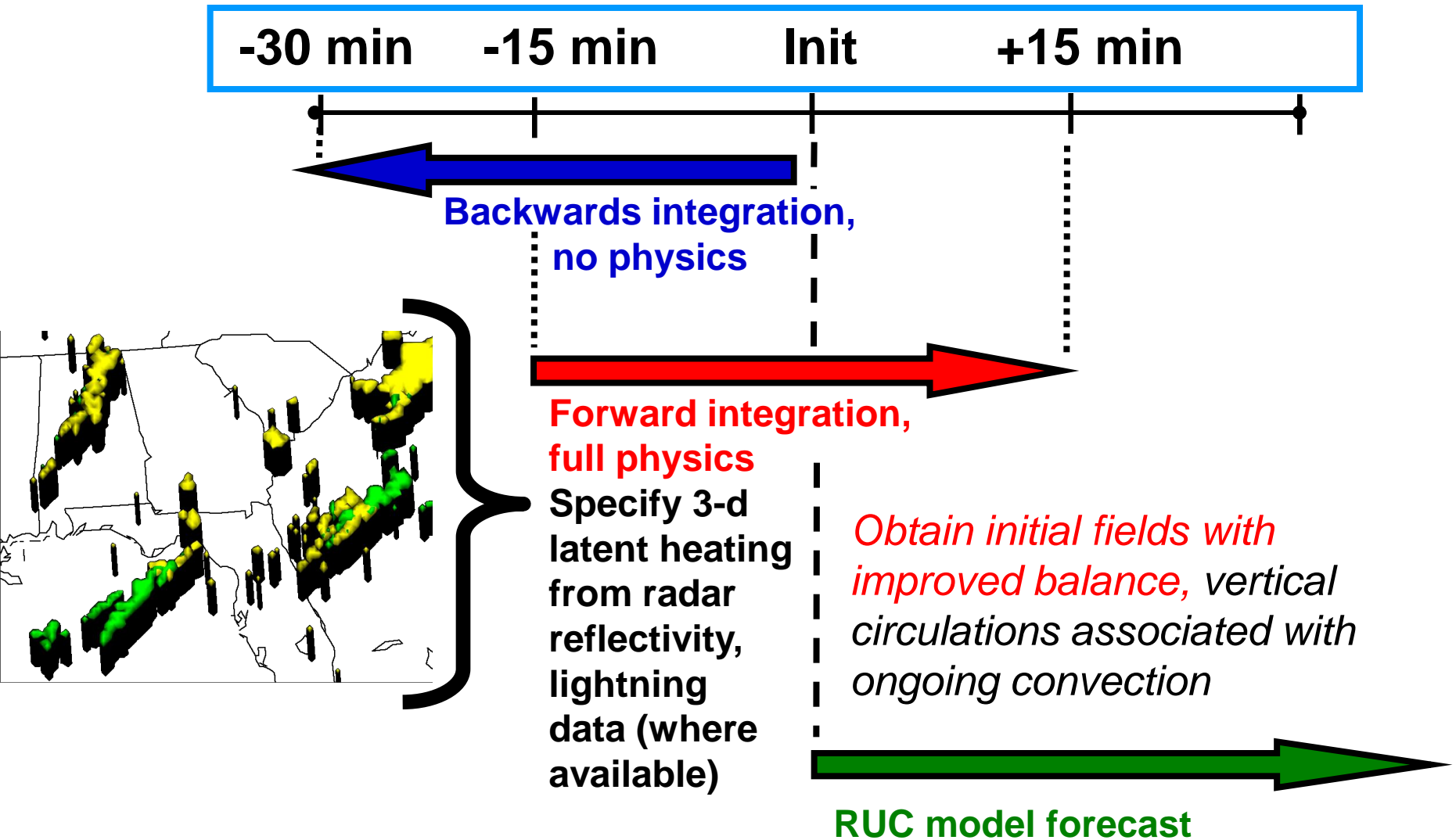
Model –
RUC model
or
WRF

Application within model
pre-forecast DFI

Forecast integration

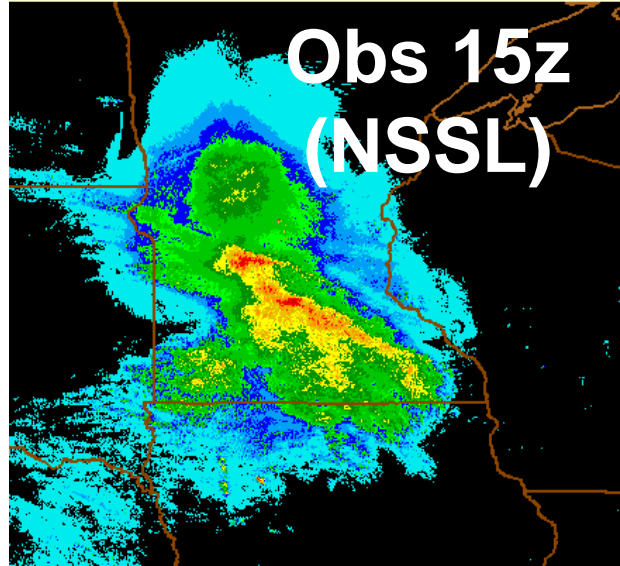
Diabatic Digital Filter Initialization (DDFI)

New - add assimilation of radar data



Radar reflectivity assimilation in RUC and Rapid Refresh

**Obs 15z
(NSSL)**

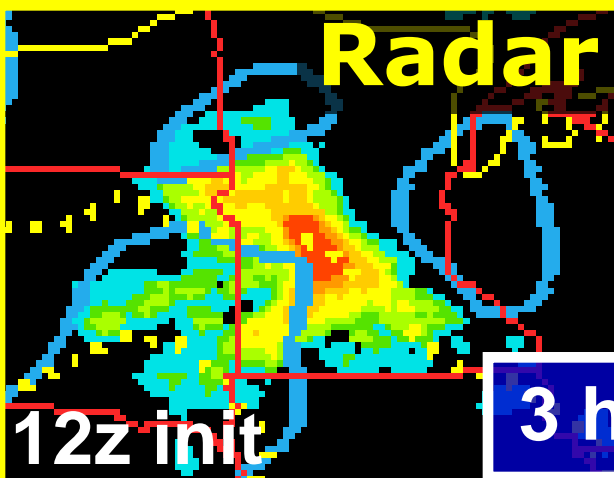


**3-h acc.
precip.**

**Valid 15z
31 July 2008**

**RUC radar
Assimilation
→ Better RUC
forecasts**

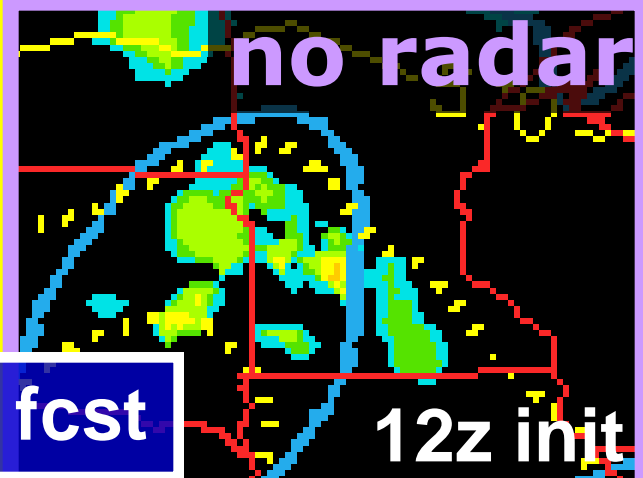
Radar



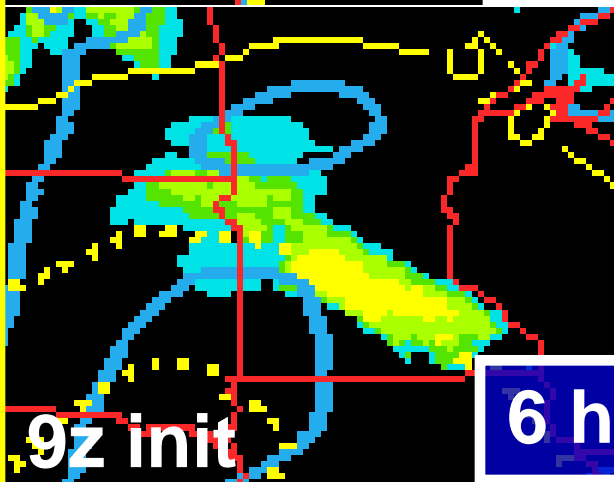
12z init

3 h fcst

no radar

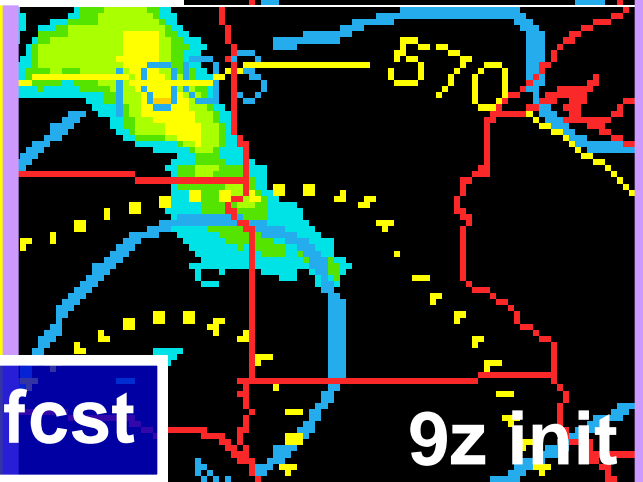


12z init

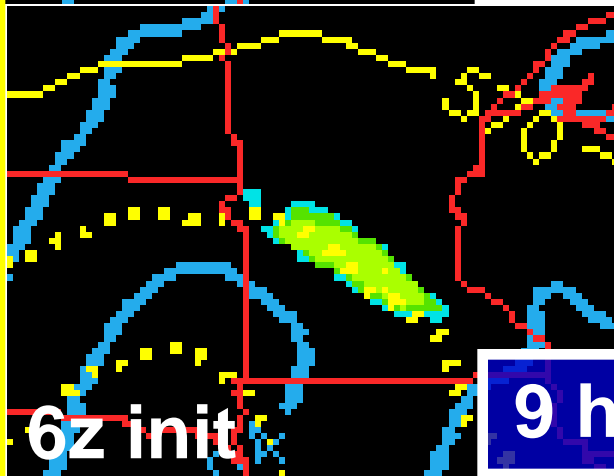


9z init

6 h fcst

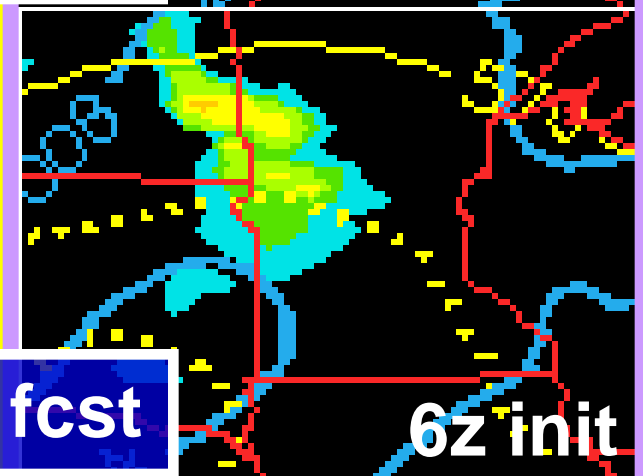


9z init



6z init

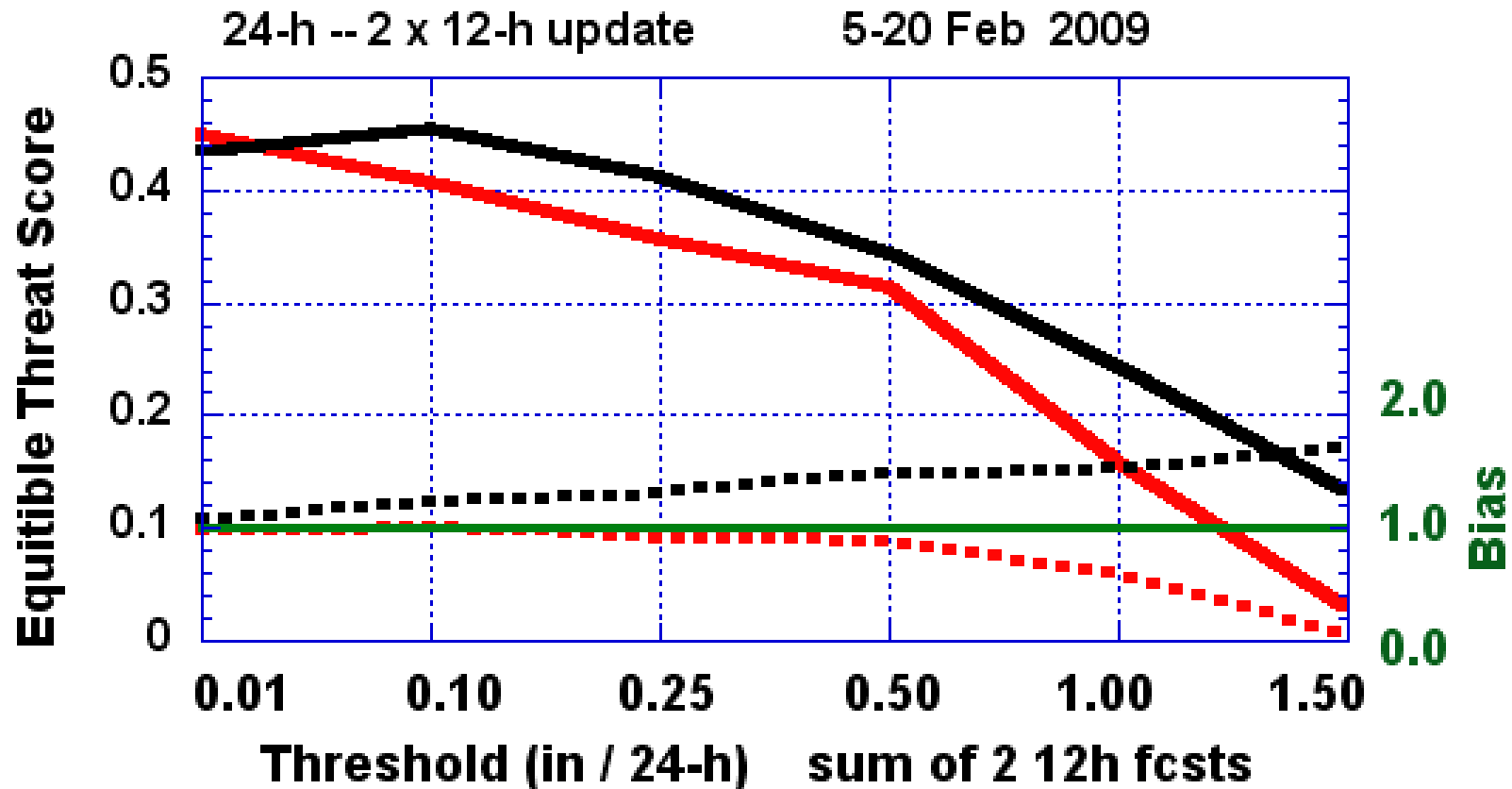
9 h fcst



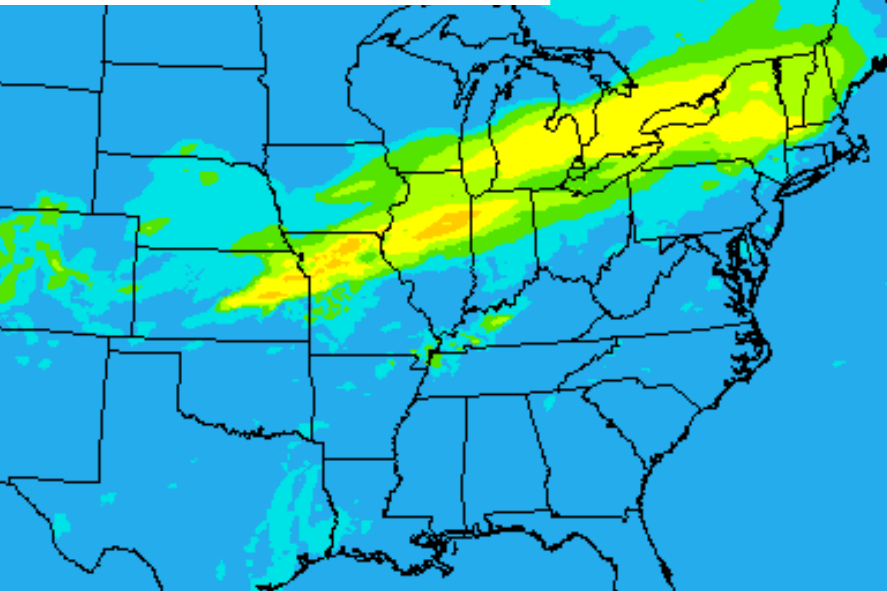
6z init

Comparison of Rapid Refresh and RUC precipitation skill scores

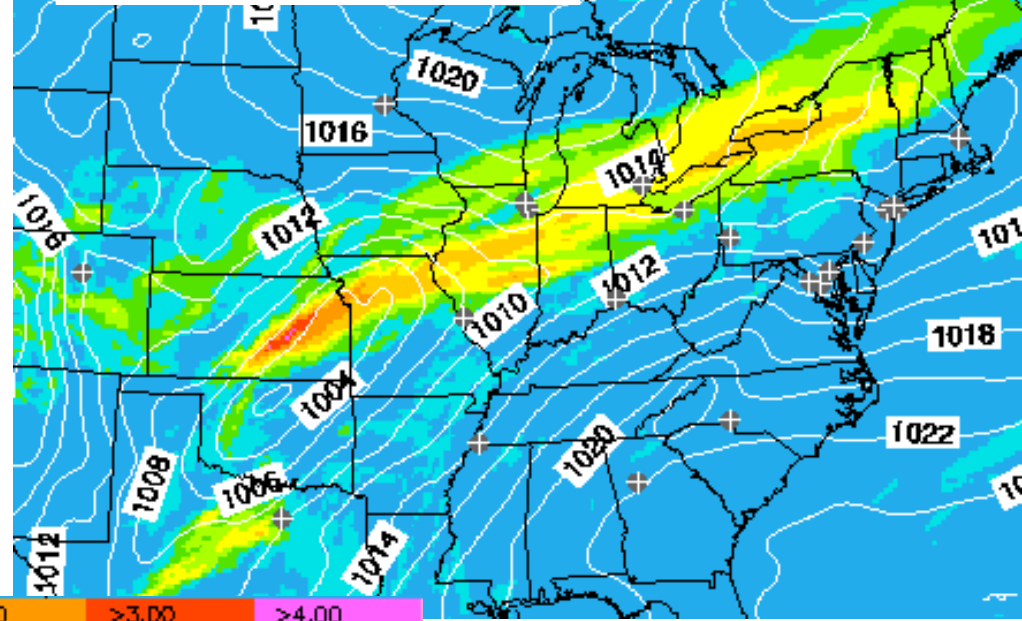
- RR has improved ETS for nearly all threshold
- RR bias higher, especially for higher thresholds



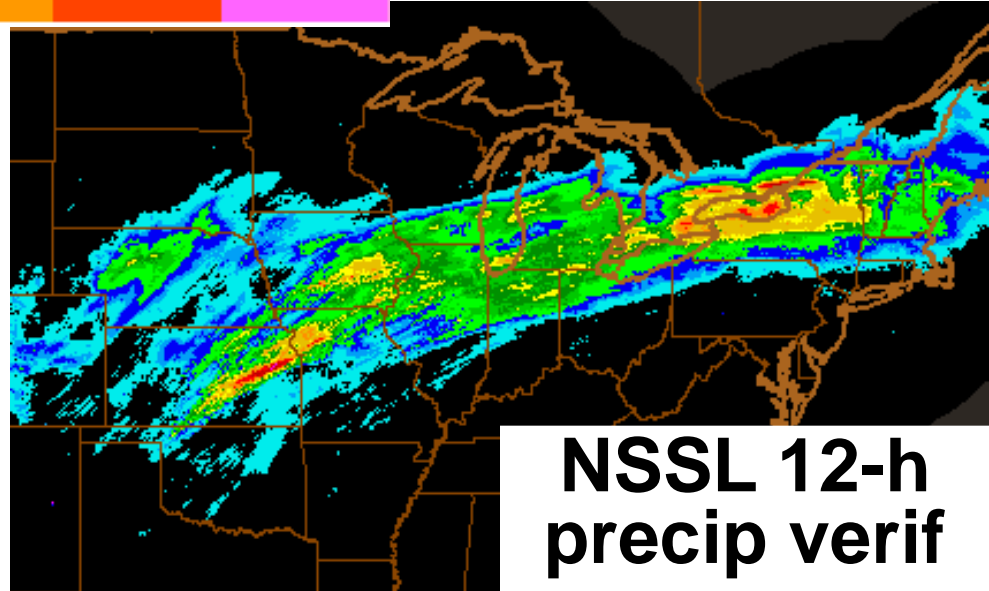
RUC 12-h fcst



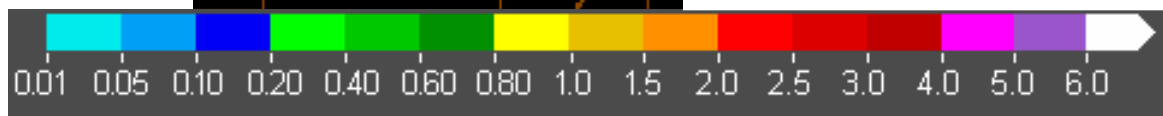
RR 12-h fcst



**12-h accum.
precipitation
06z Mar 8, 2009**

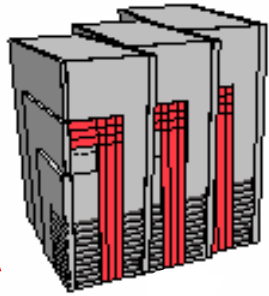


**NSSL 12-h
precip verif**

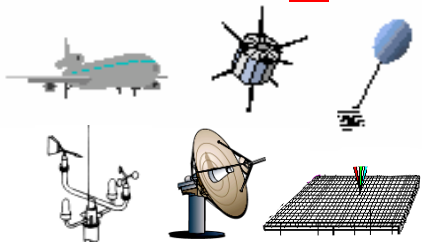


RUC / RR and HRRR models

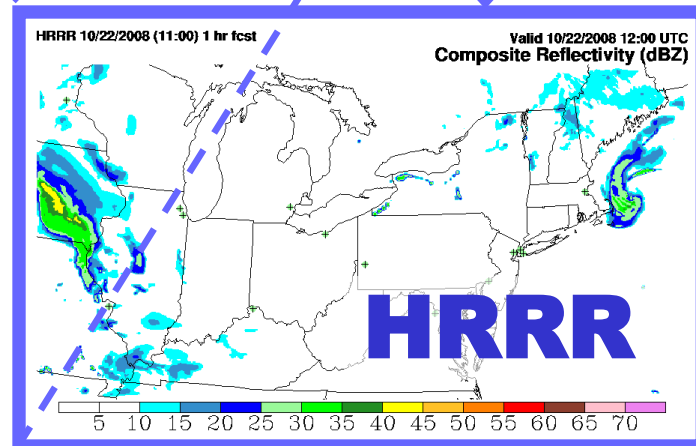
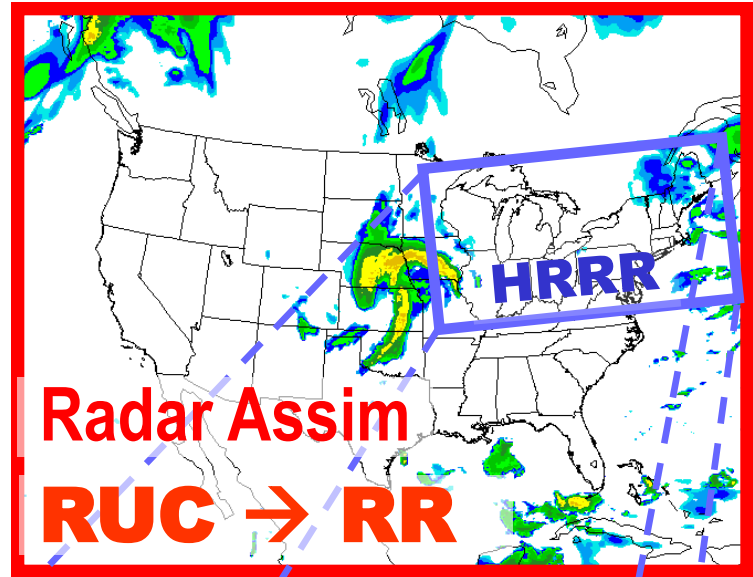
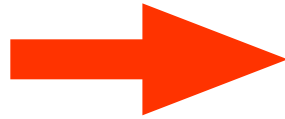
Hourly updating model



Data Assimilation cycle

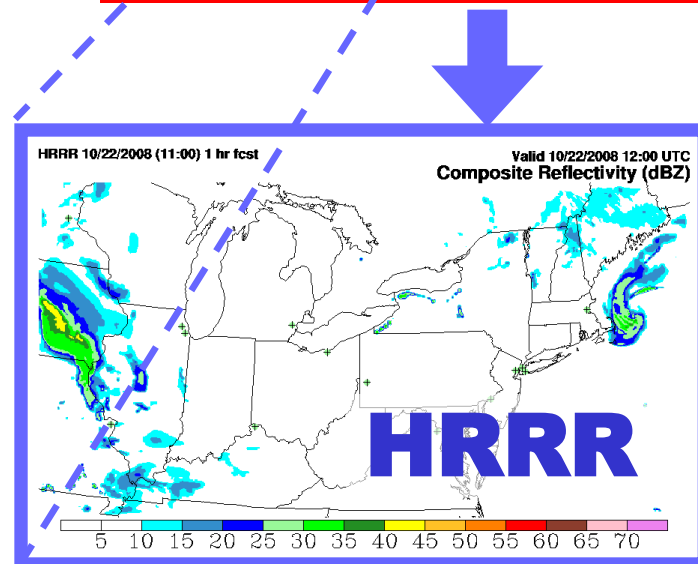
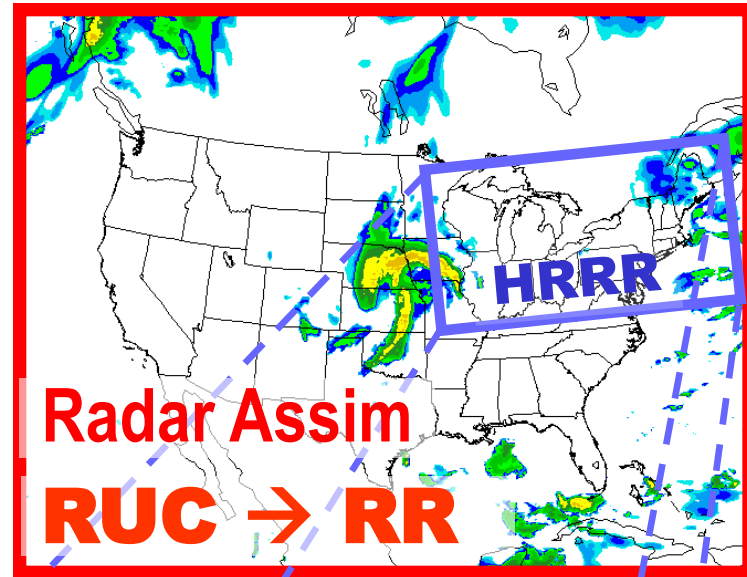
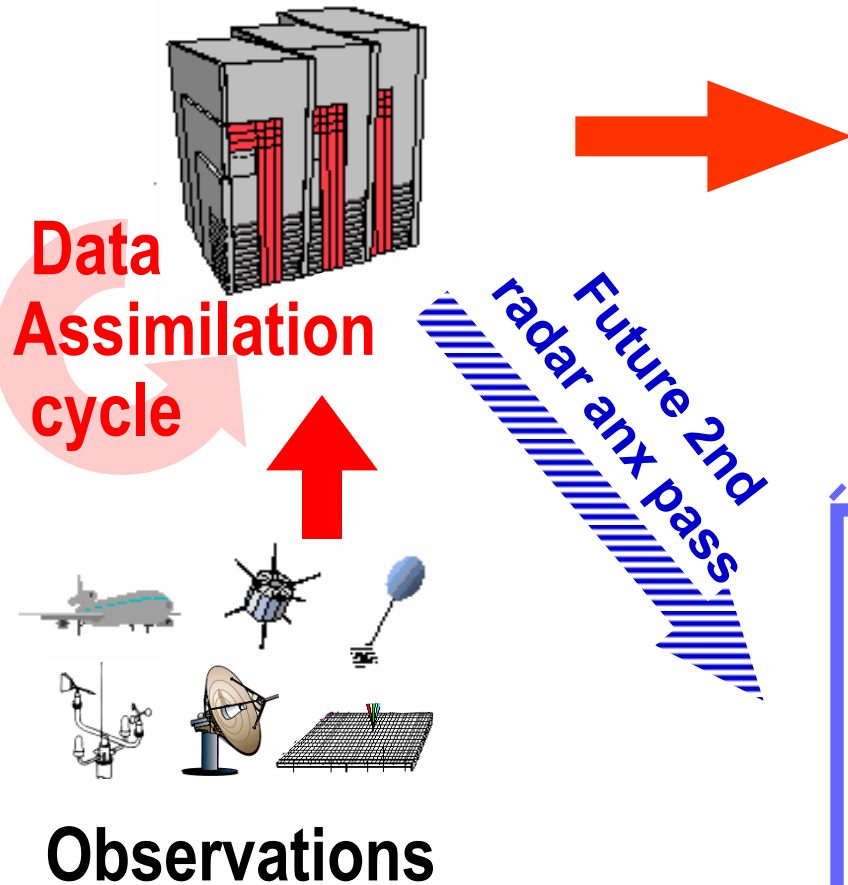


Observations



RUC / RR and HRRR models

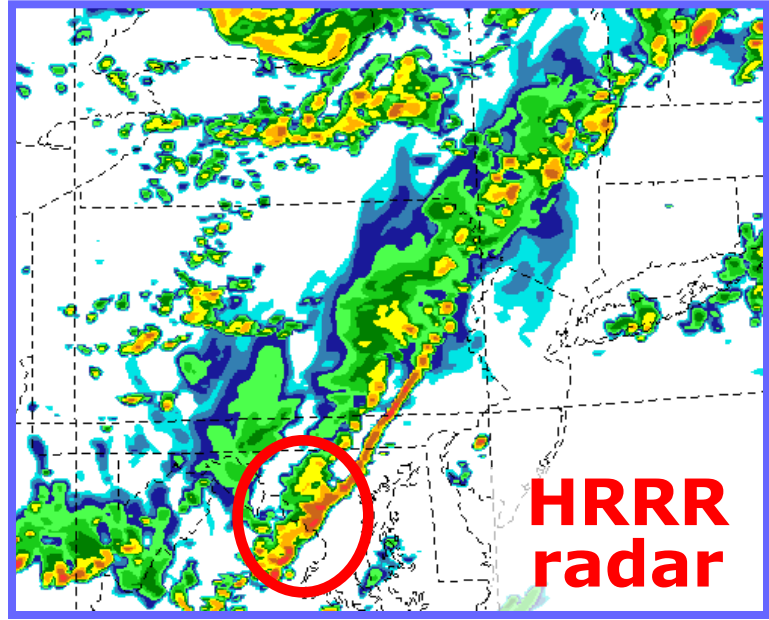
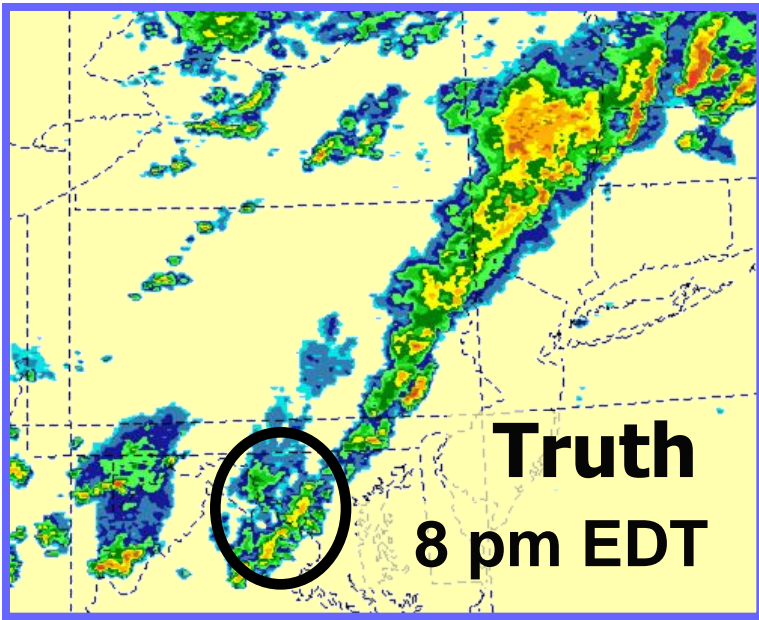
Hourly updating model



HRRR with radar DA → storm details, right places

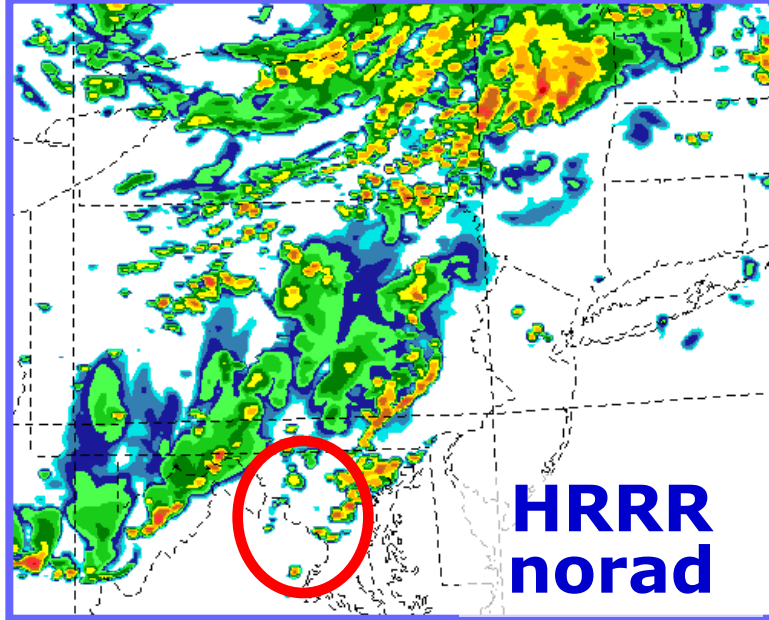
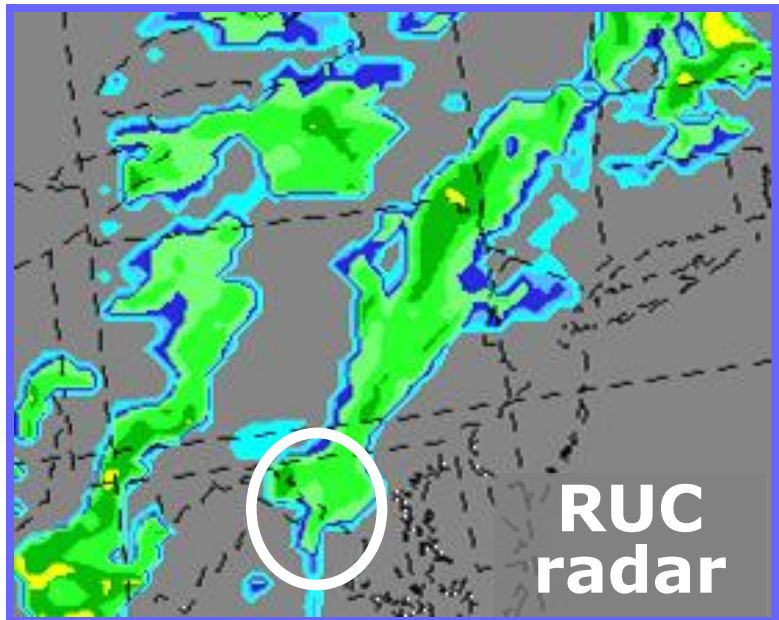
20 July
2008

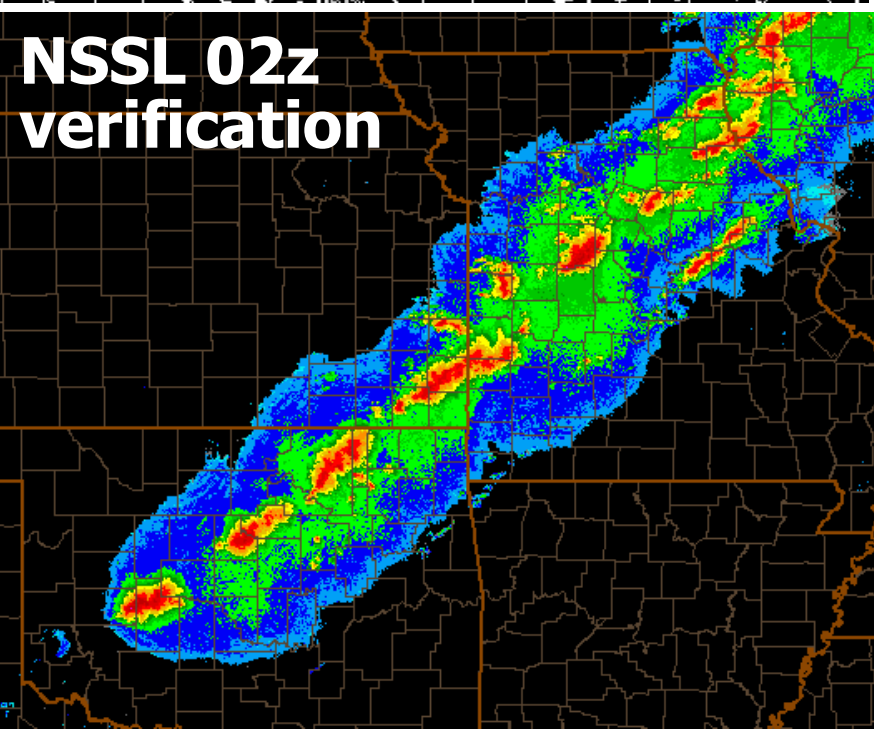
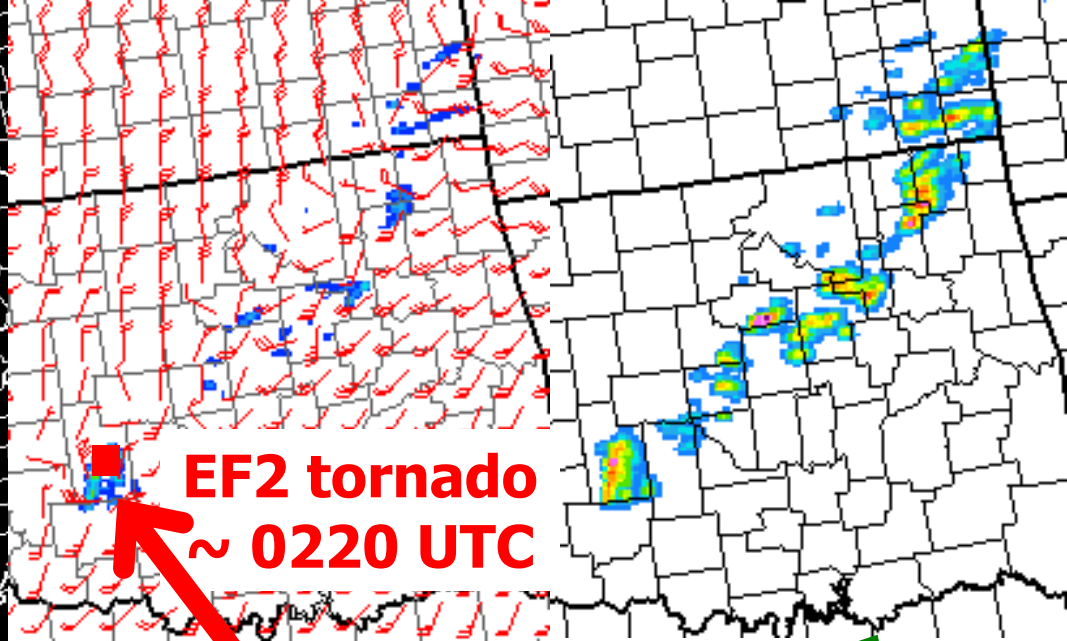
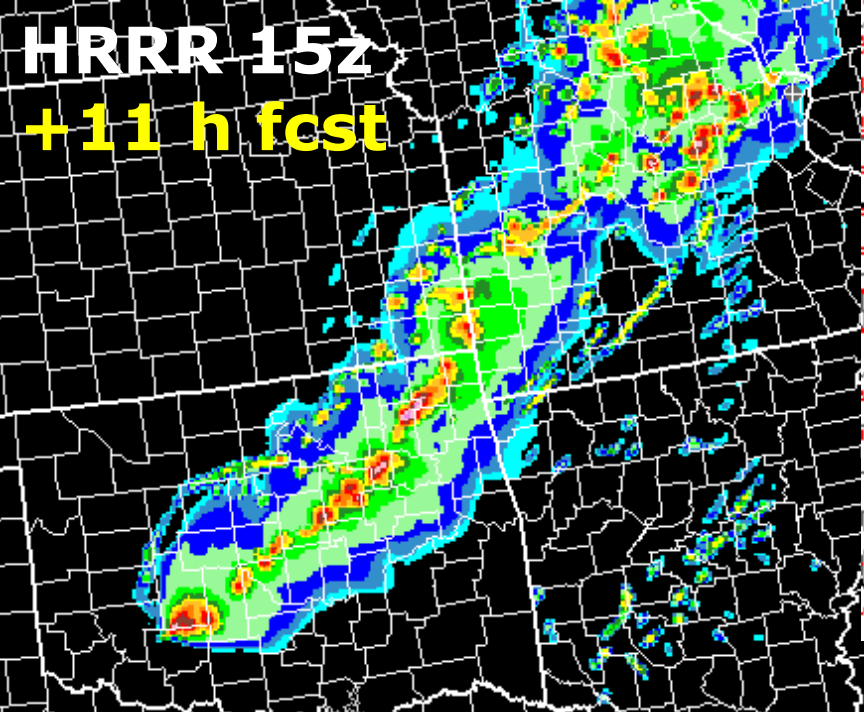
2 pm
initial
Time



8 pm
valid
time

+ 6h
fcsts





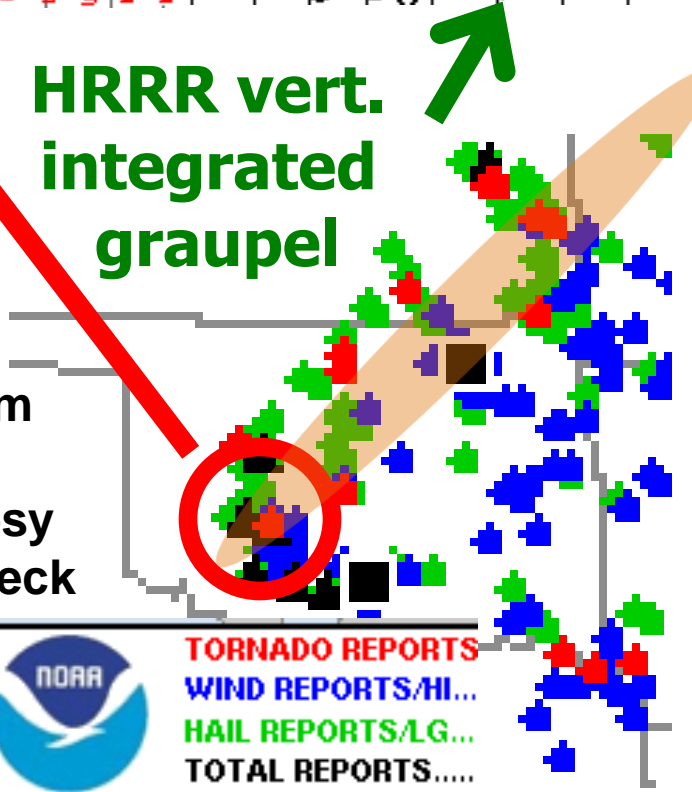
**HRRR
updraft
helicity**

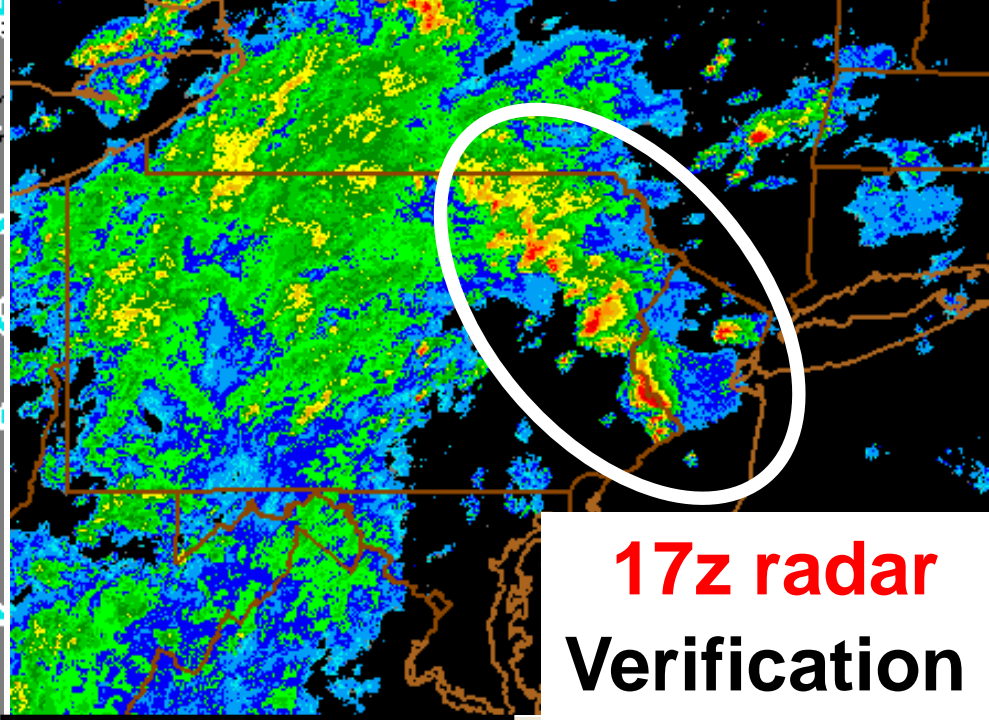
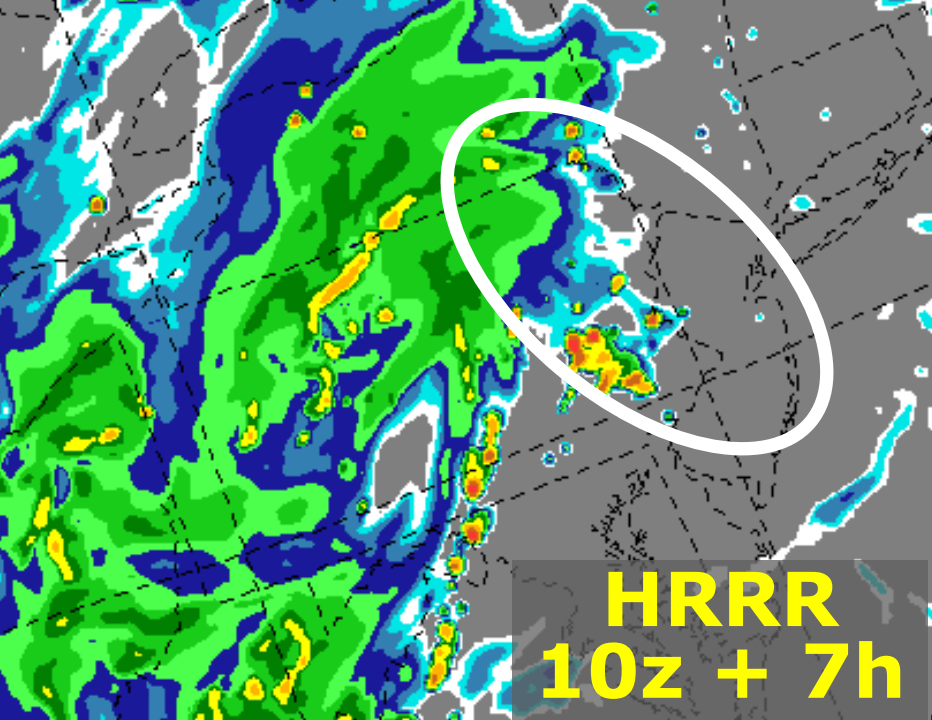
**HRRR vert.
integrated
graupel**

Severe storm
diagnostics
code courtesy
Scott Dembeck
and NSSL

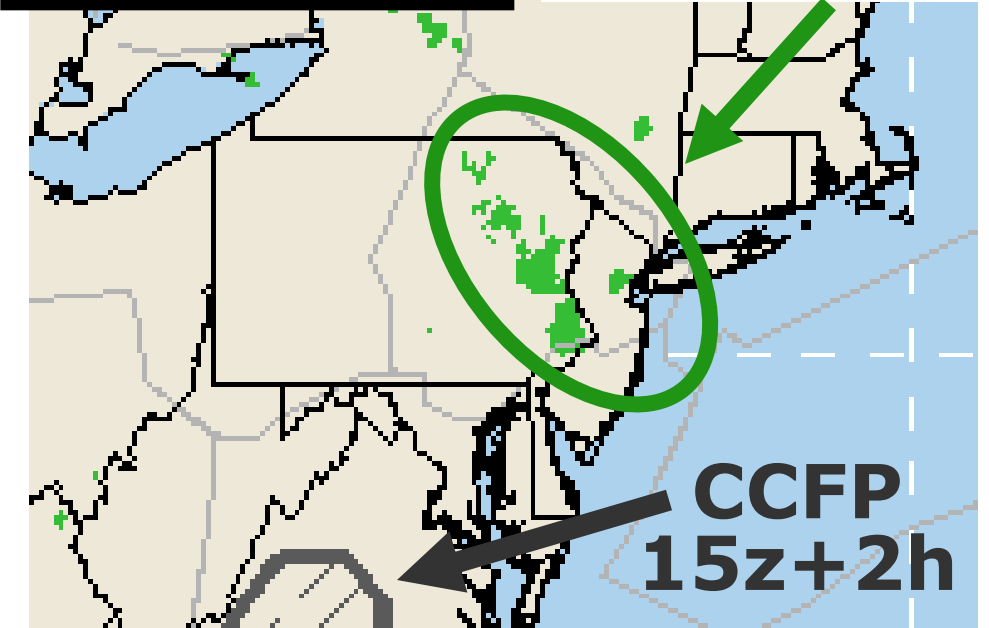
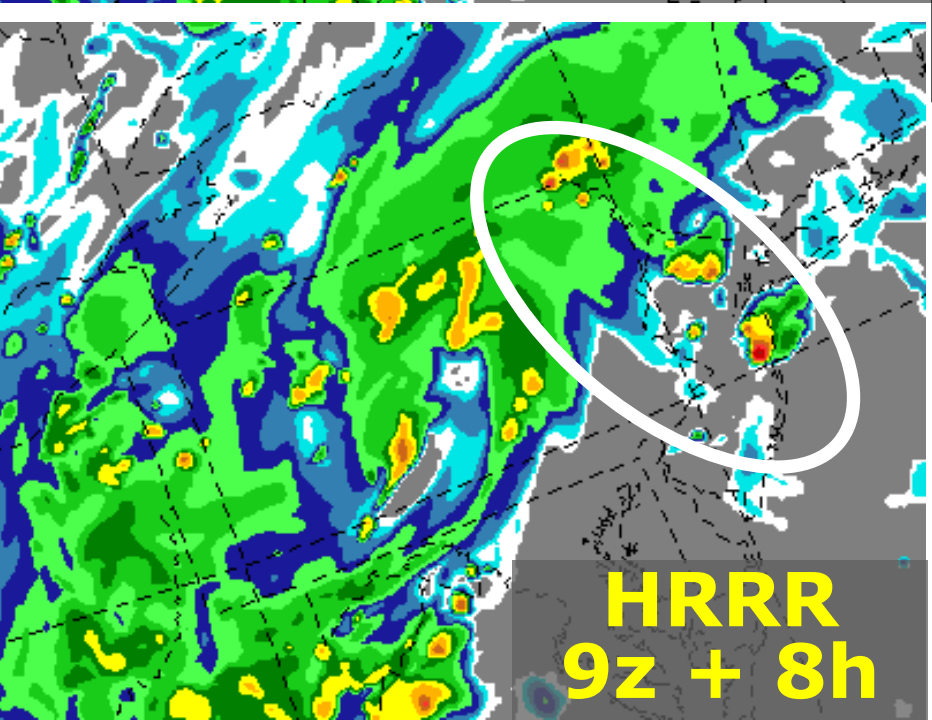


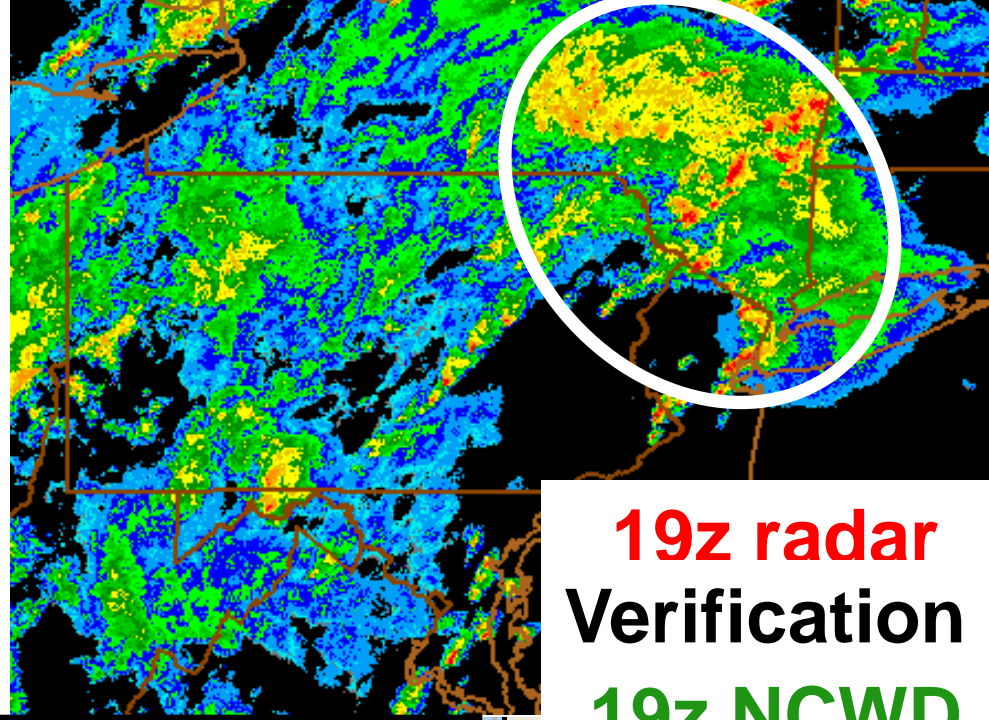
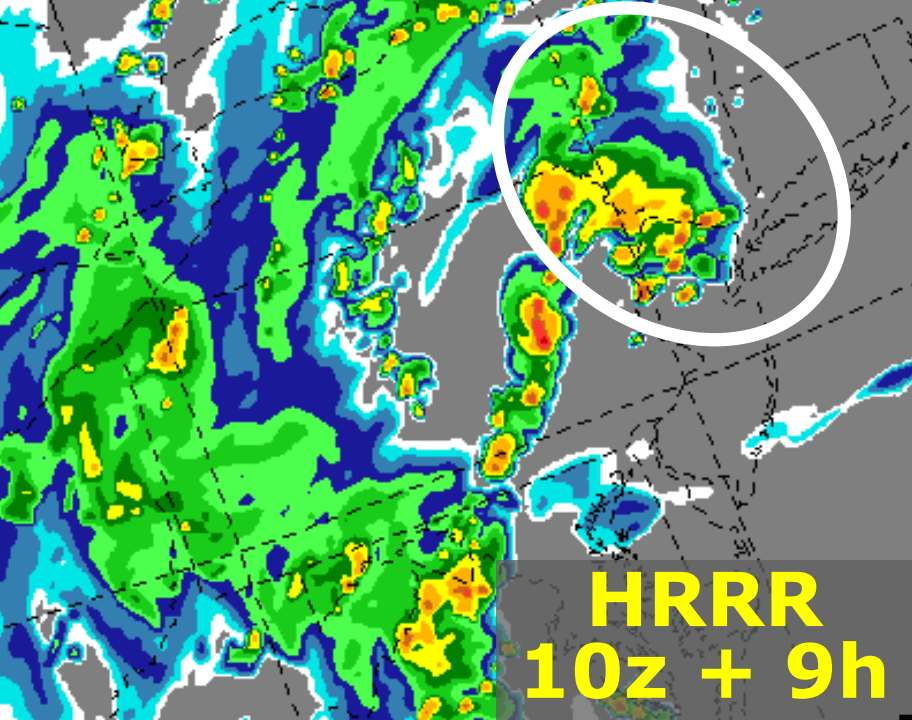
TORNADO REPORTS
WIND REPORTS/HI...
HAIL REPORTS/LG...
TOTAL REPORTS.....



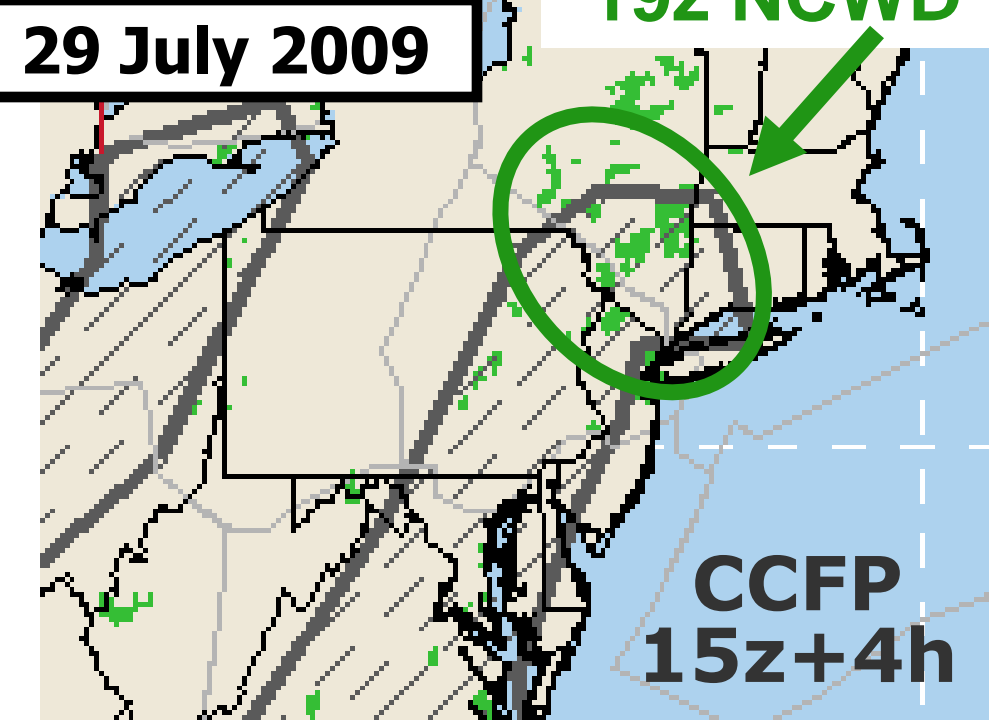
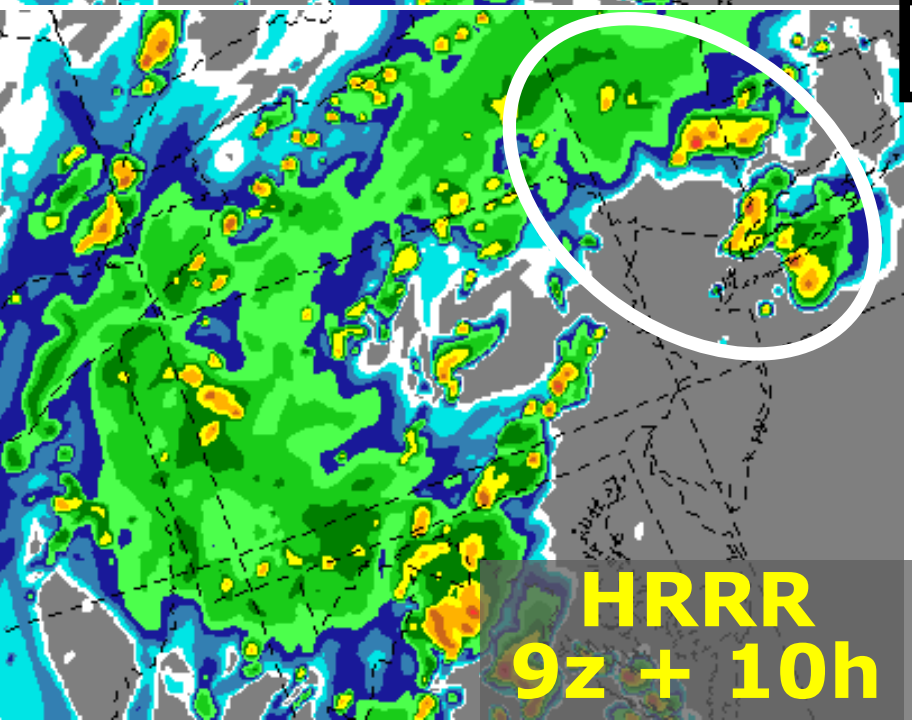


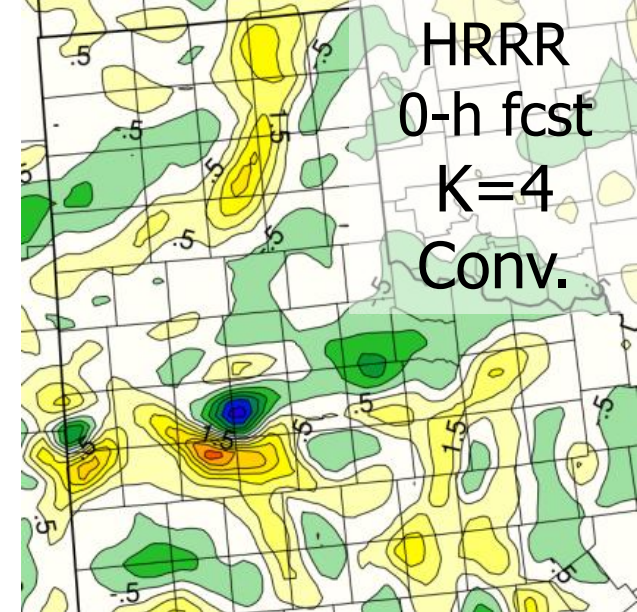
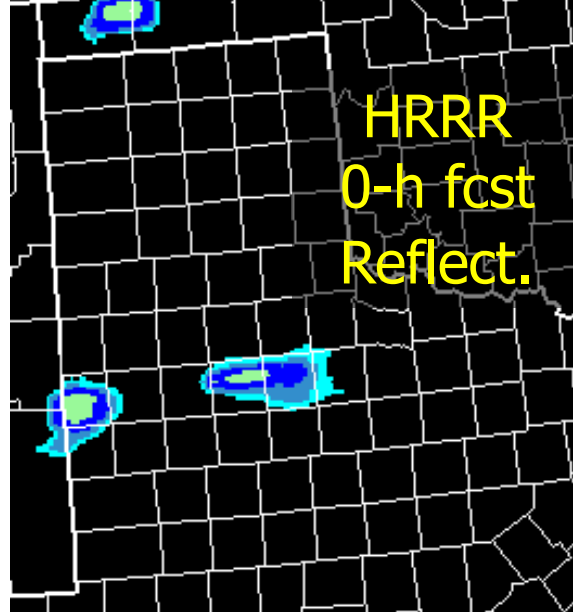
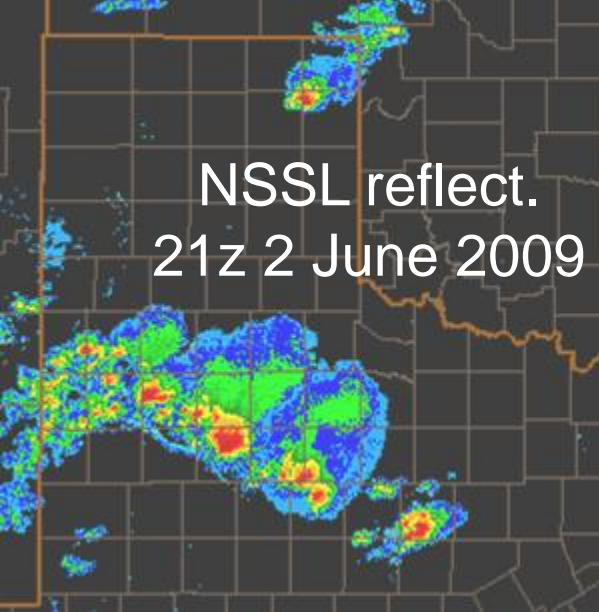
July 29, 2009



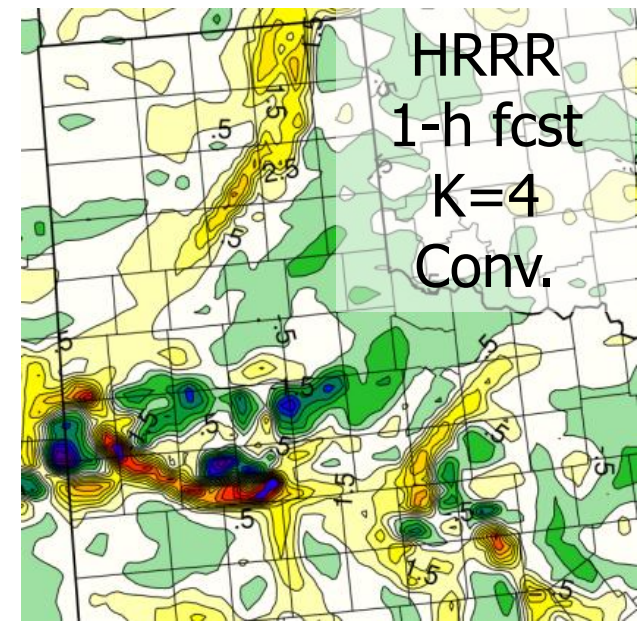
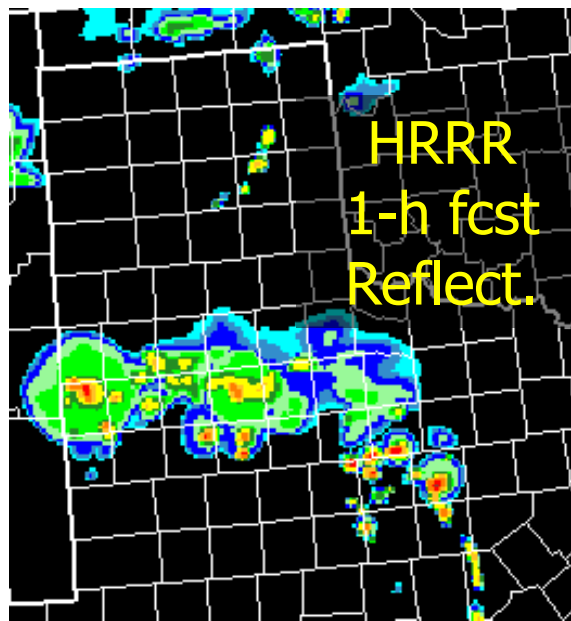
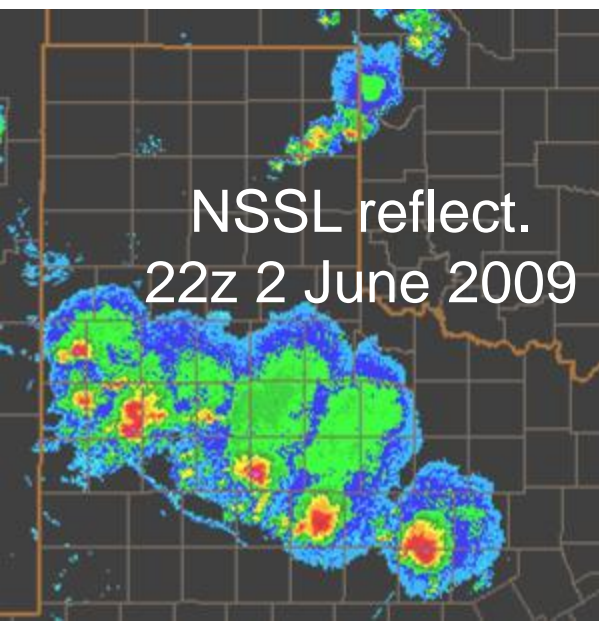
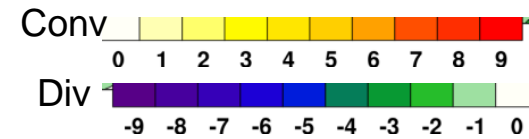


29 July 2009

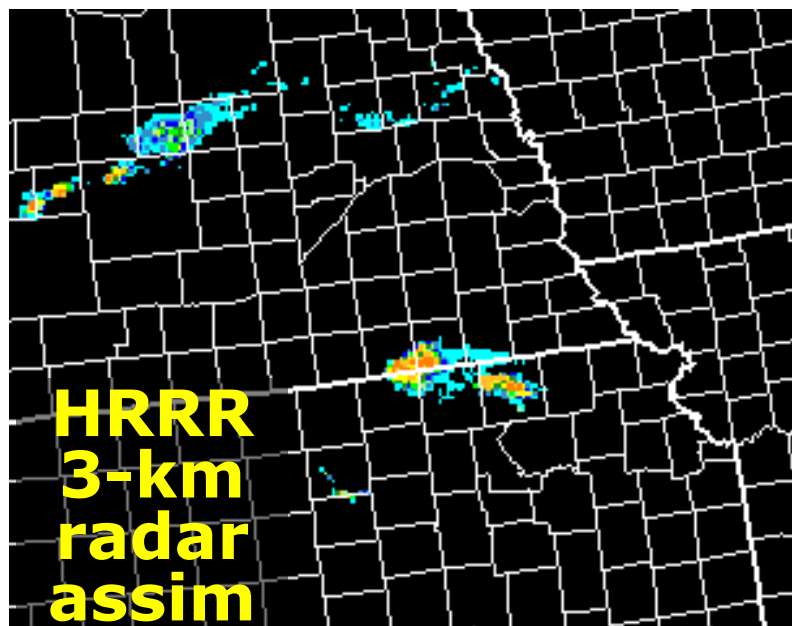
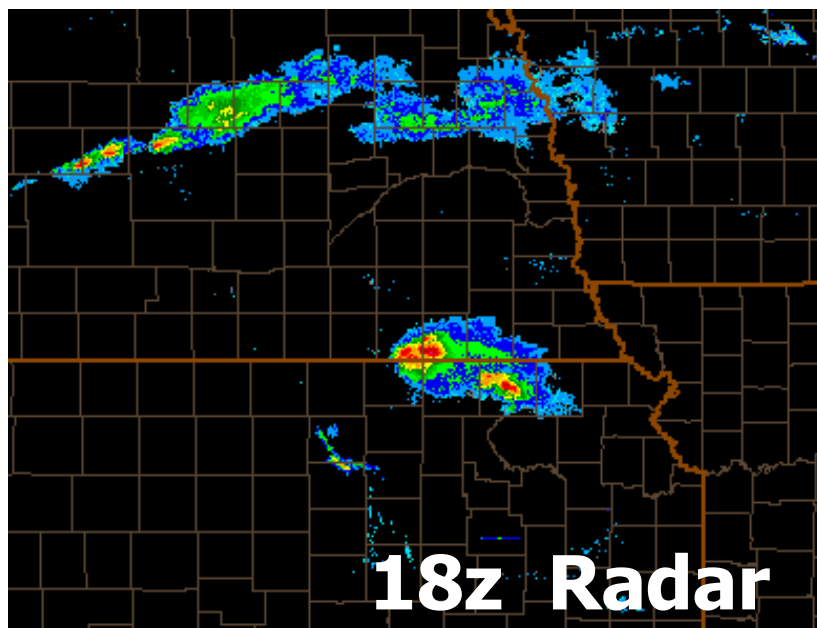




DFI impact on HRRR fields



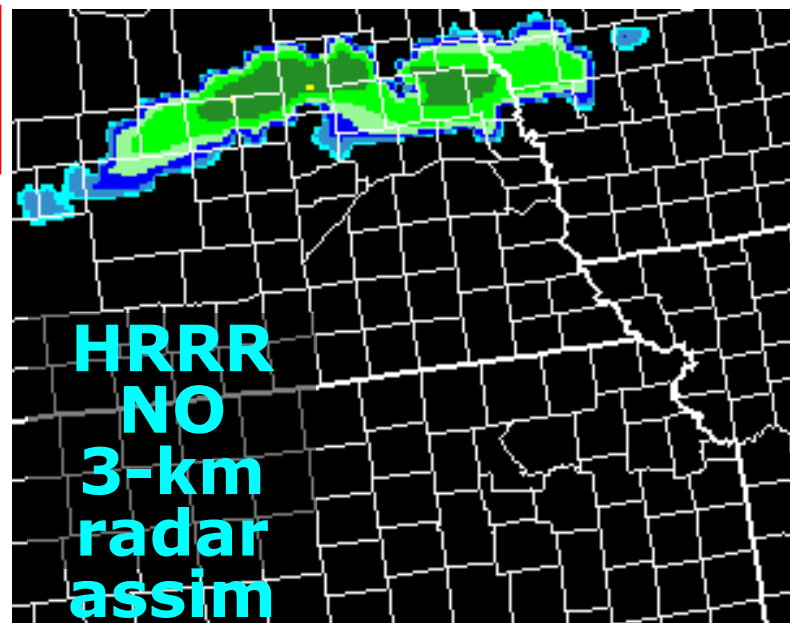
HRRR with 2nd pass radar DA on 3-km domain



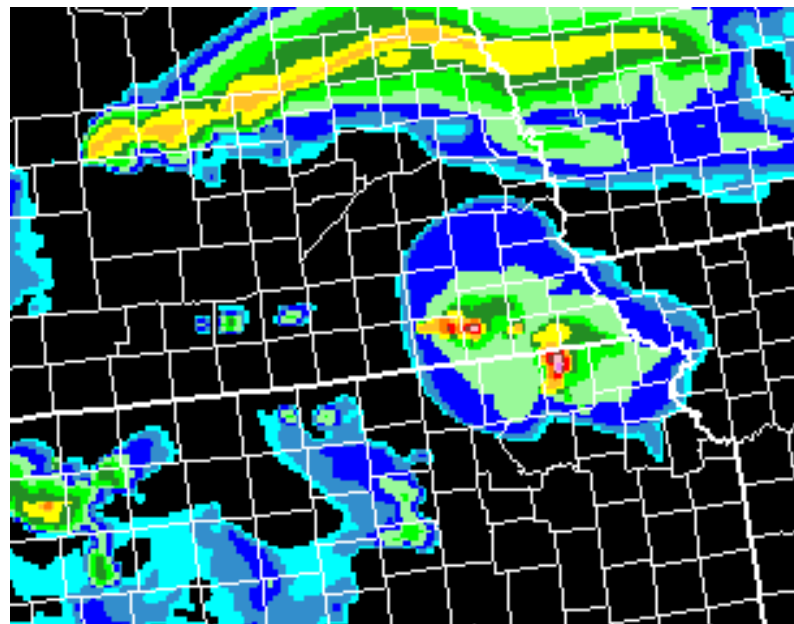
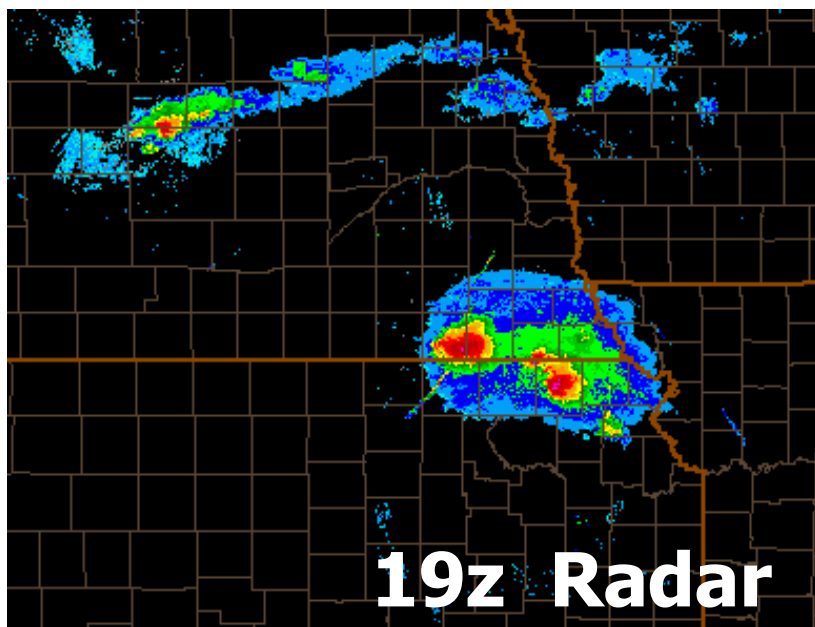
27 June 2009

+ 0h
fcsts

- Both fcsts have RUC 13-km DFI radar reflectivity assimilation
- 13-km radar DA → conv/div → storms
- 2nd pass (3-km radar DA with DFI) greatly reduces initial spin-up
- Mix of storm- and mes-scale control of storm evolution evident in forecast



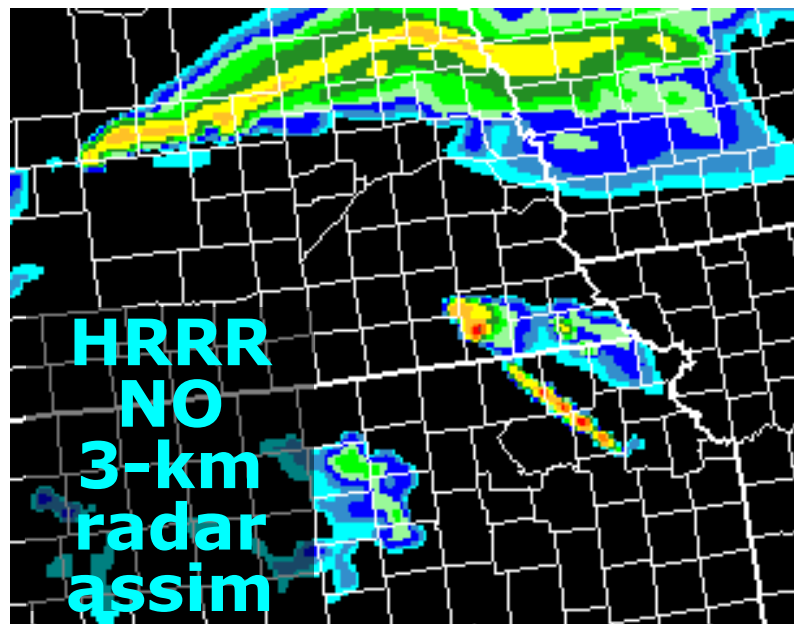
HRRR with 2nd pass radar DA on 3-km domain



27 June 2009

+ 1h
fcsts

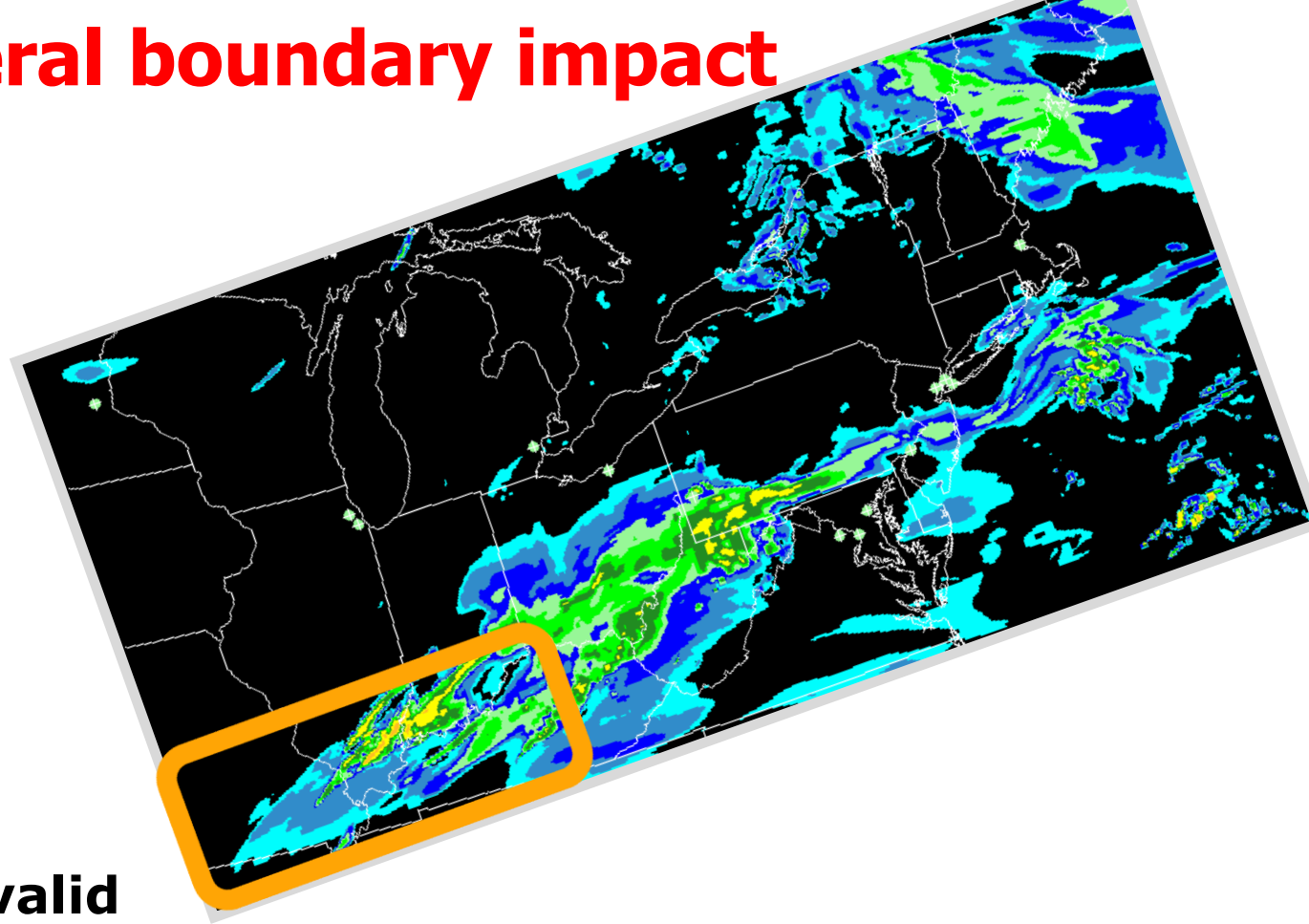
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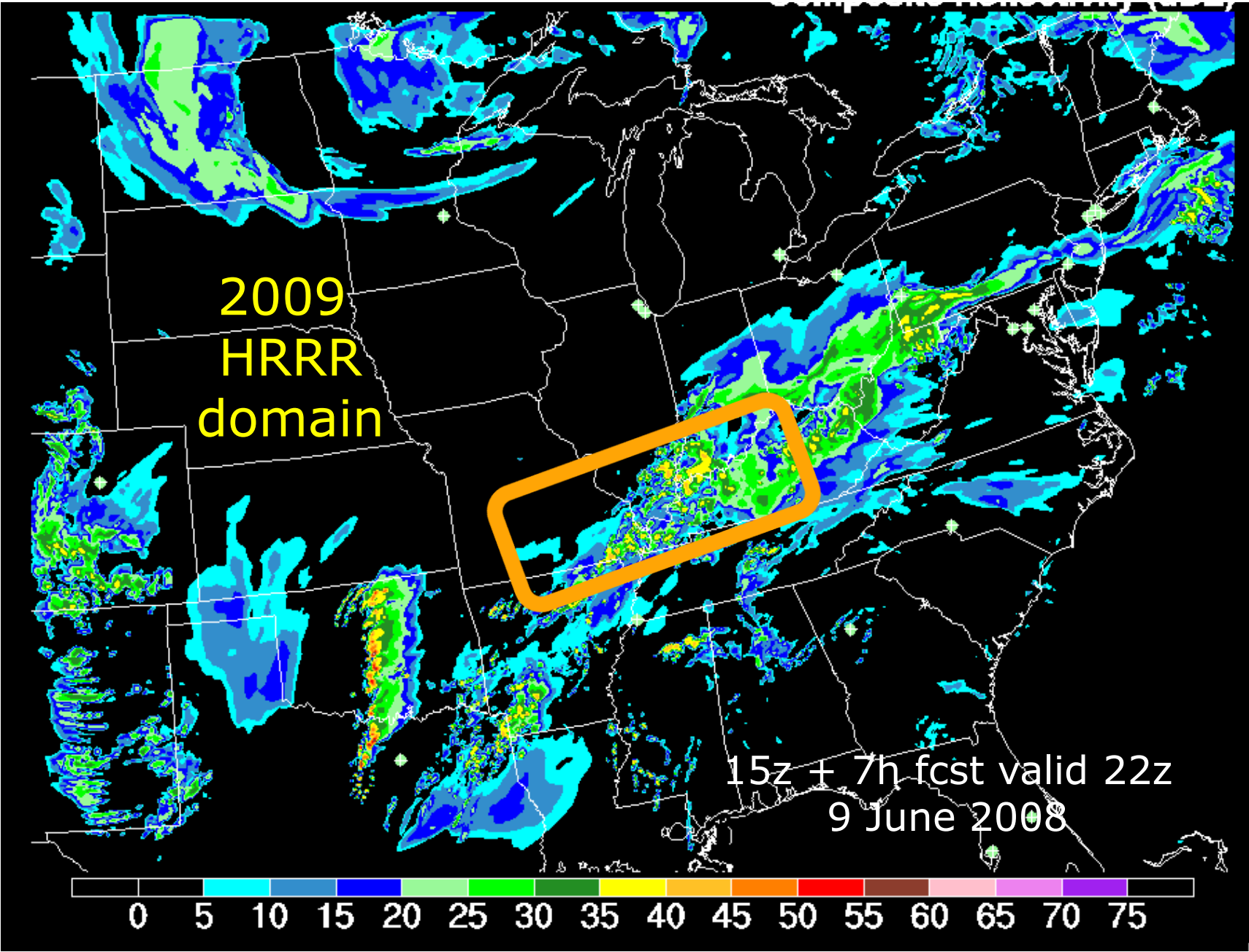
Negative lateral boundary impact

**2008 NE
Corridor
HRRR
domain**

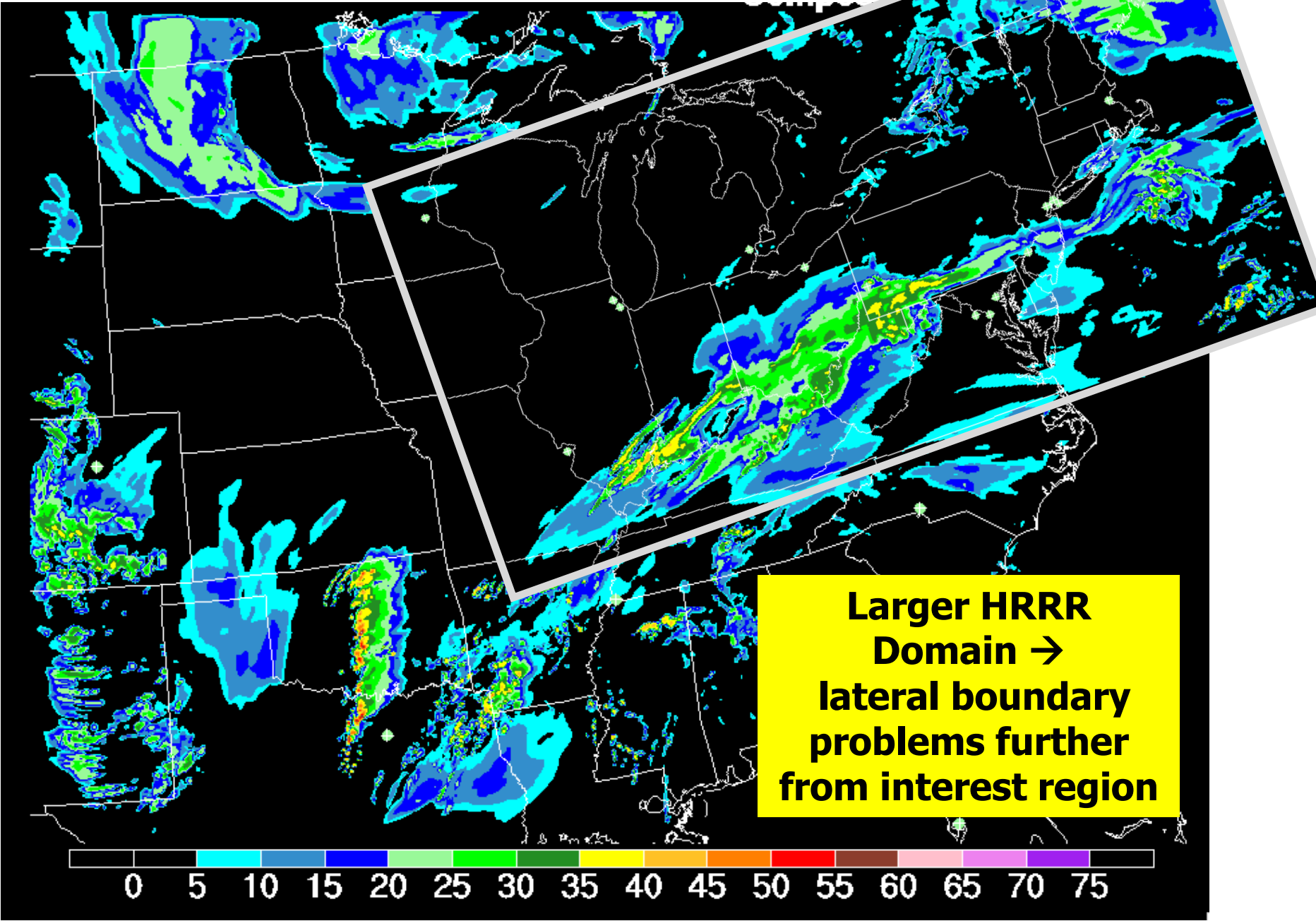
**15z + 7h fcst valid
22z 9 June 2008**



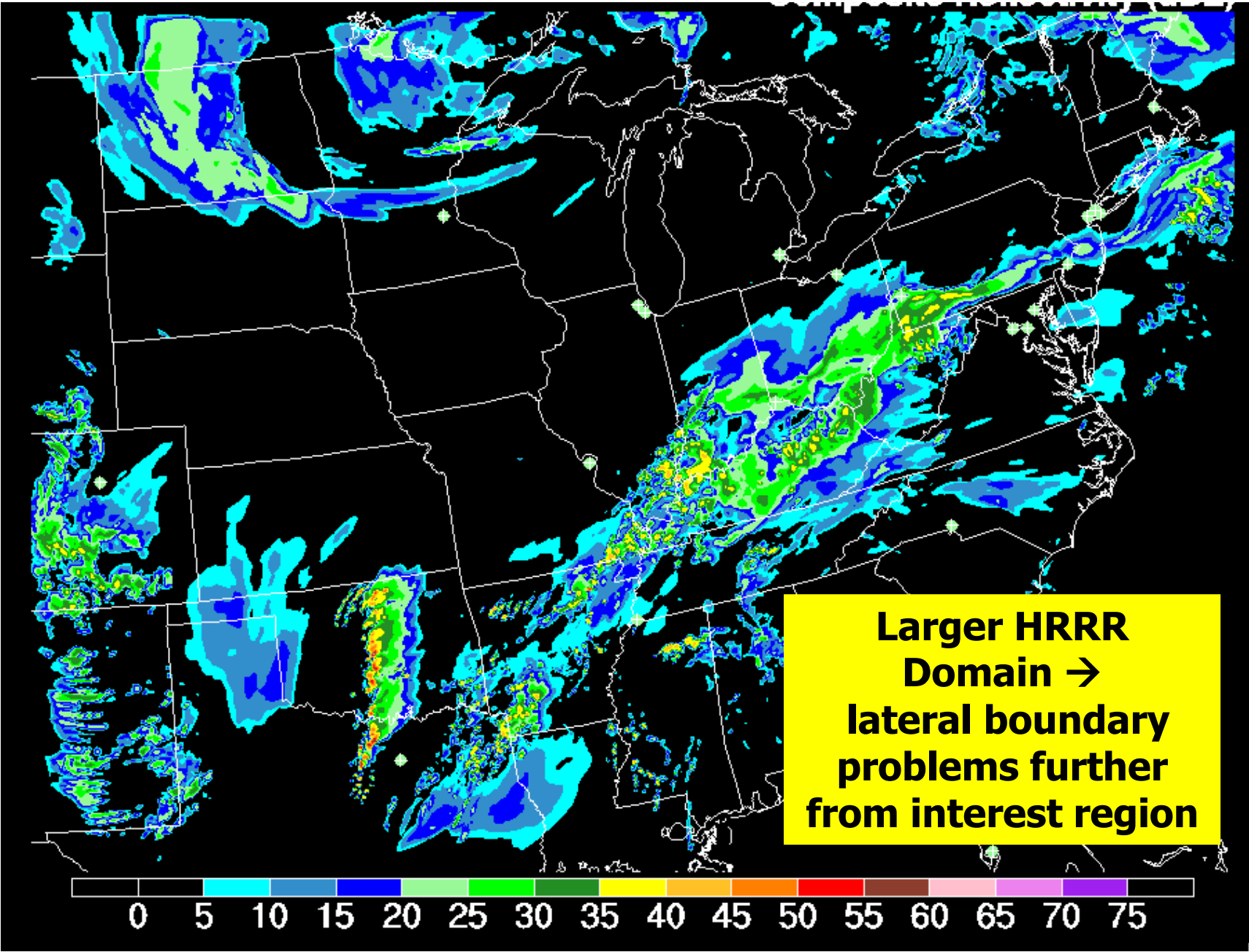
Negative lateral boundary impact



Negative lateral boundary impact

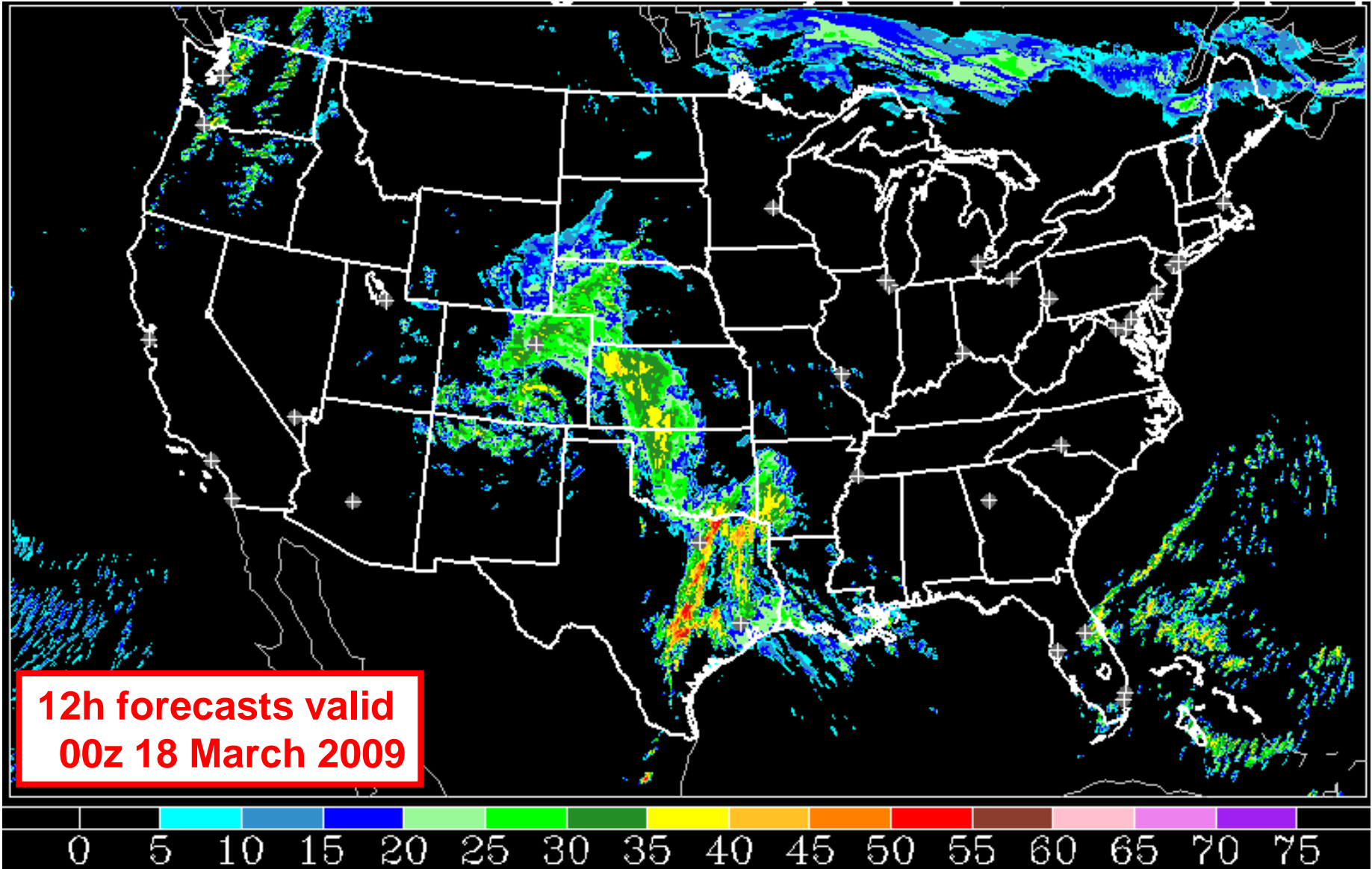


Negative lateral boundary impact

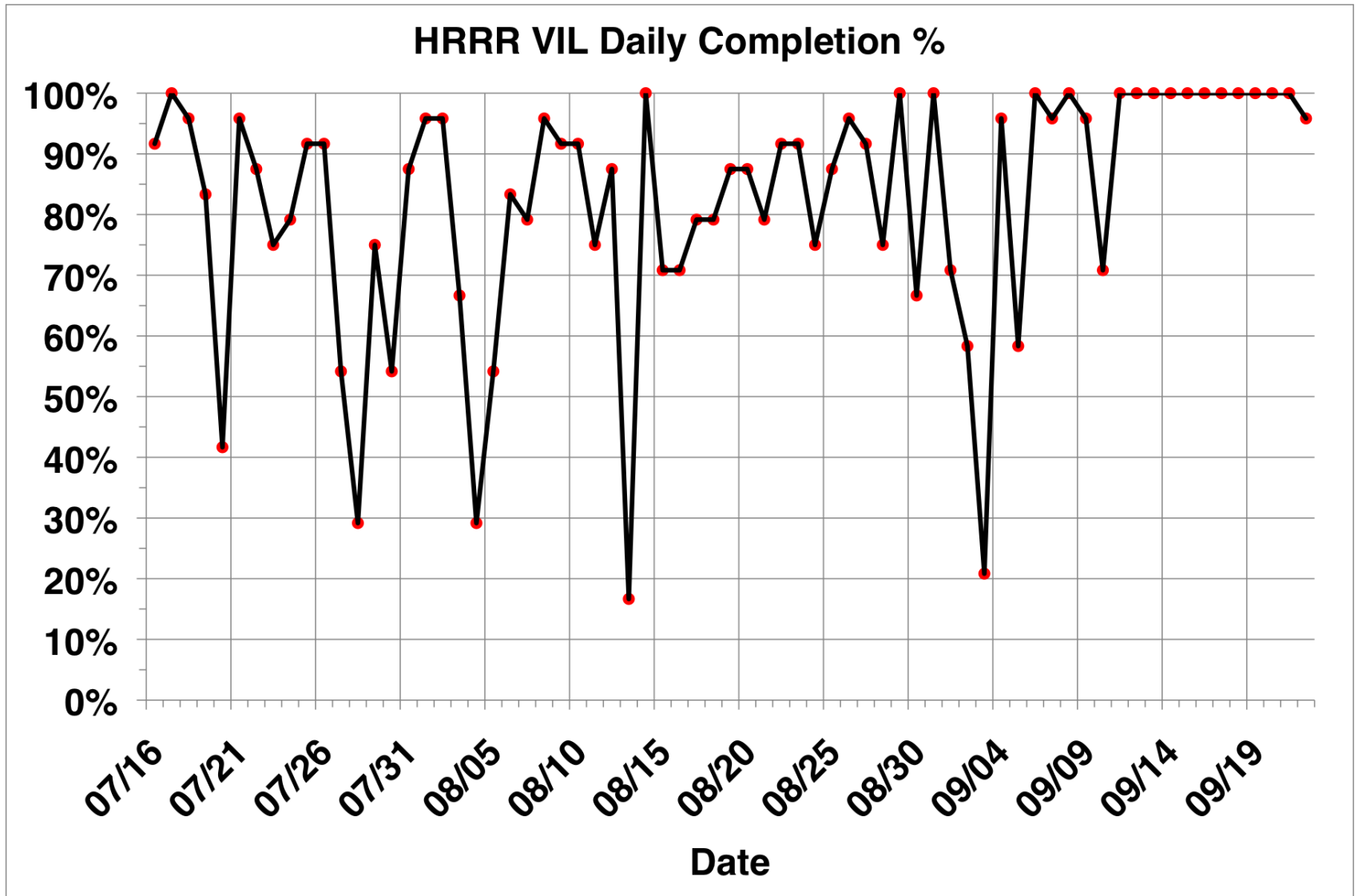


CONUS HRRR domain for 2010

1820 x 1060 GPs -- hourly runs to +15h, ~ 2h latency



HRRR availability this summer - disk hardware failure, recovery



RUC, Rapid
Refresh and
HRRR

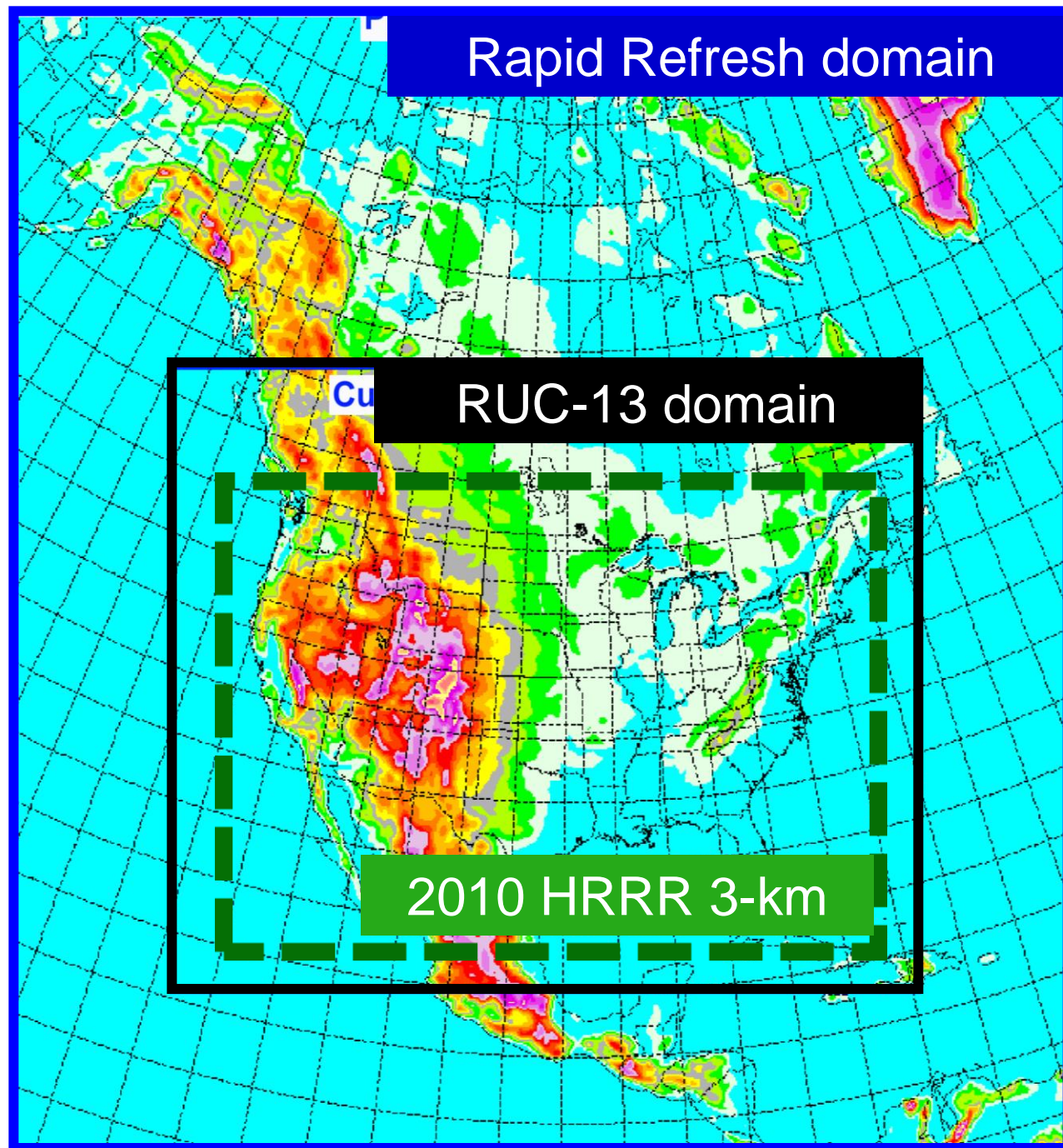
**Time-lagged
ensembles**

RUC

**RCPF = RUC
Conv Prob Fcst**

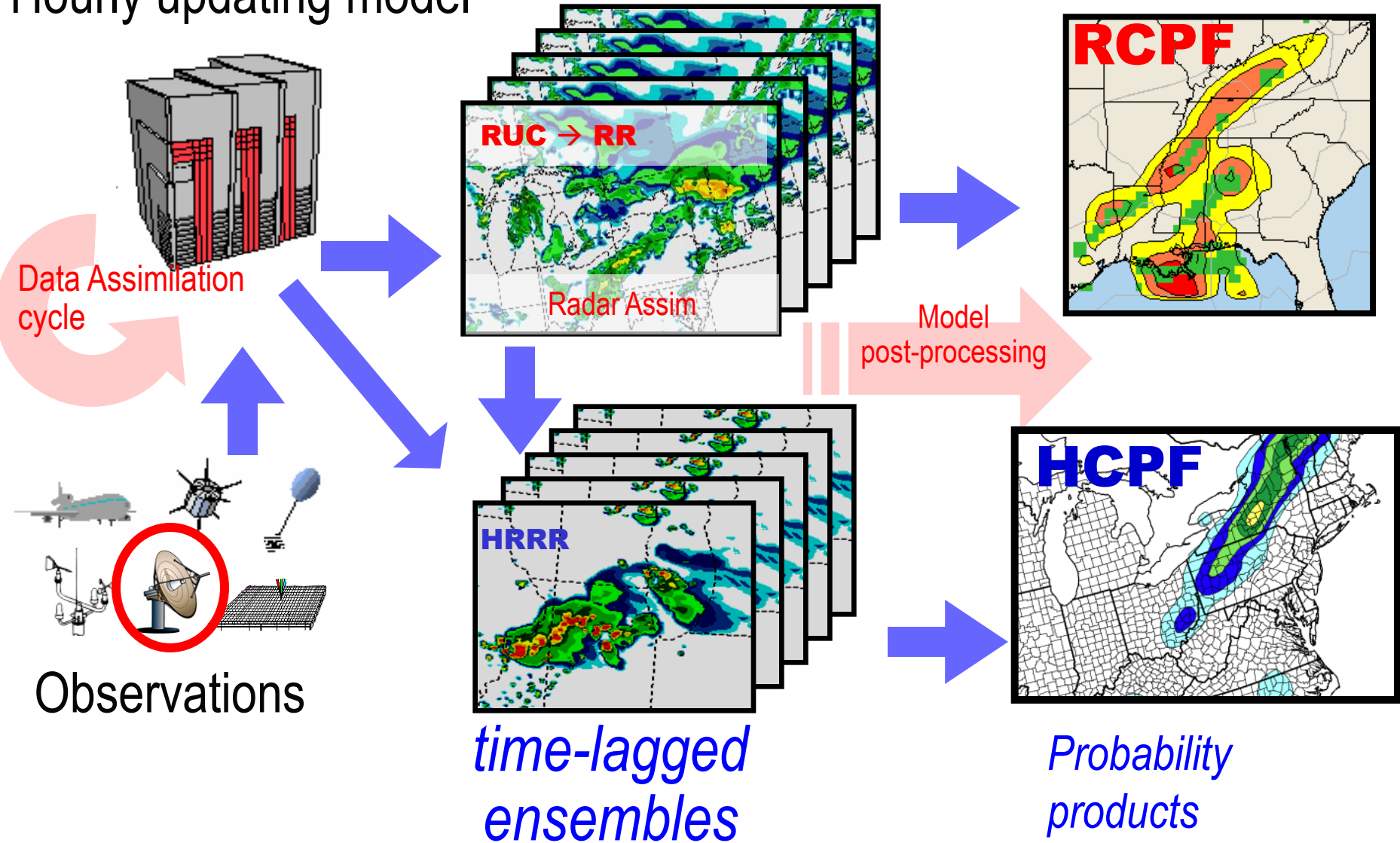
HRRR

**HC PF = HRRR
Conv Prob Fcst**



Model-based storm guidance

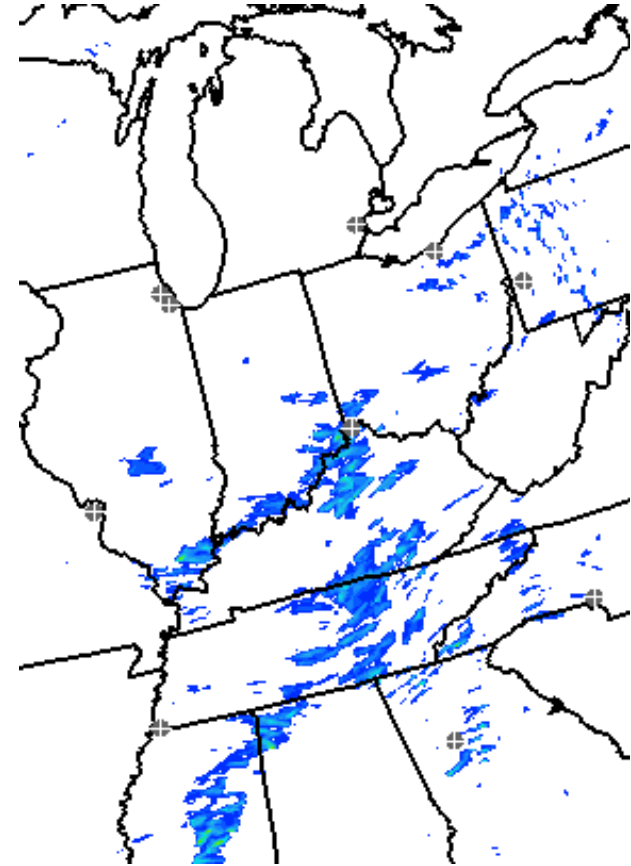
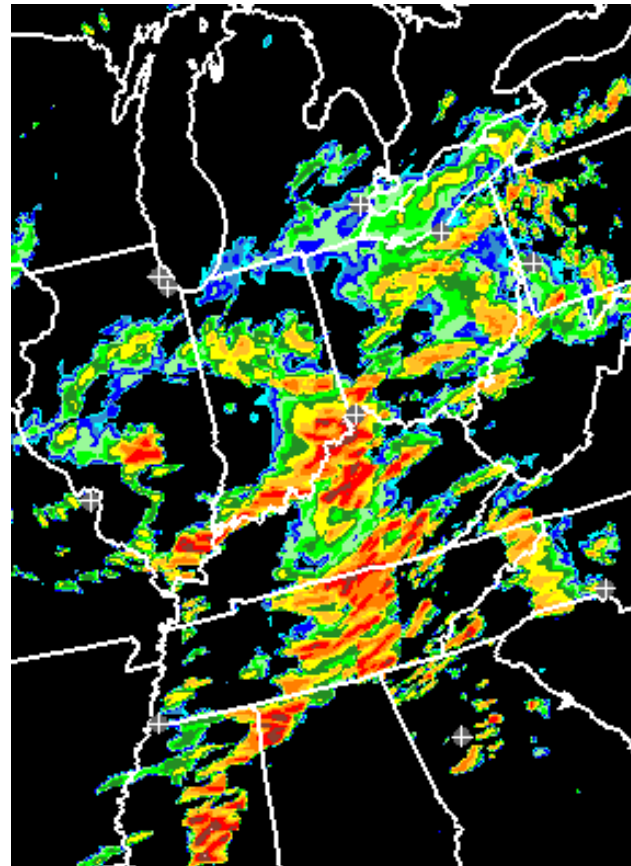
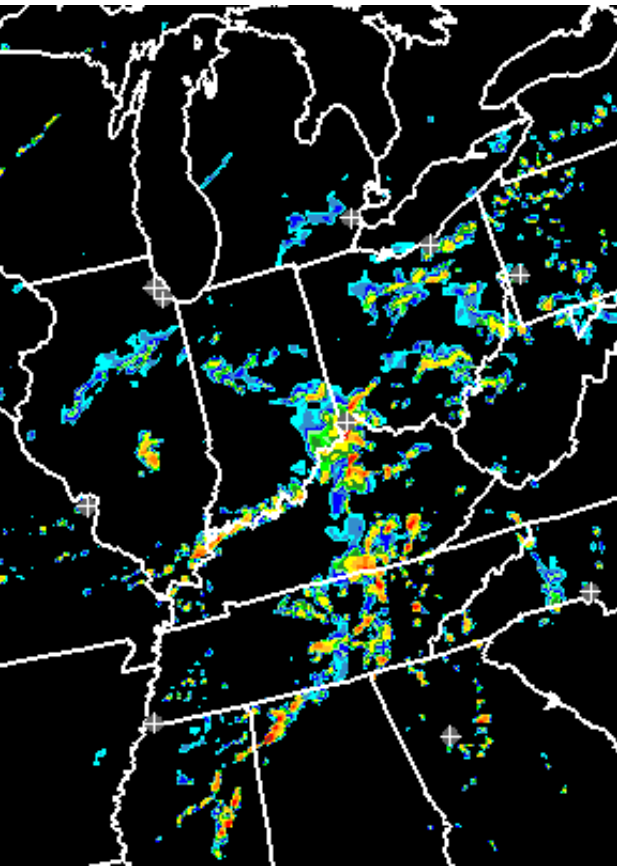
Hourly updating model



Selection of predictors

Instantaneous reflectivity suffers from phase errors

Using **hourly maximum** increases coverage → **better predictor**



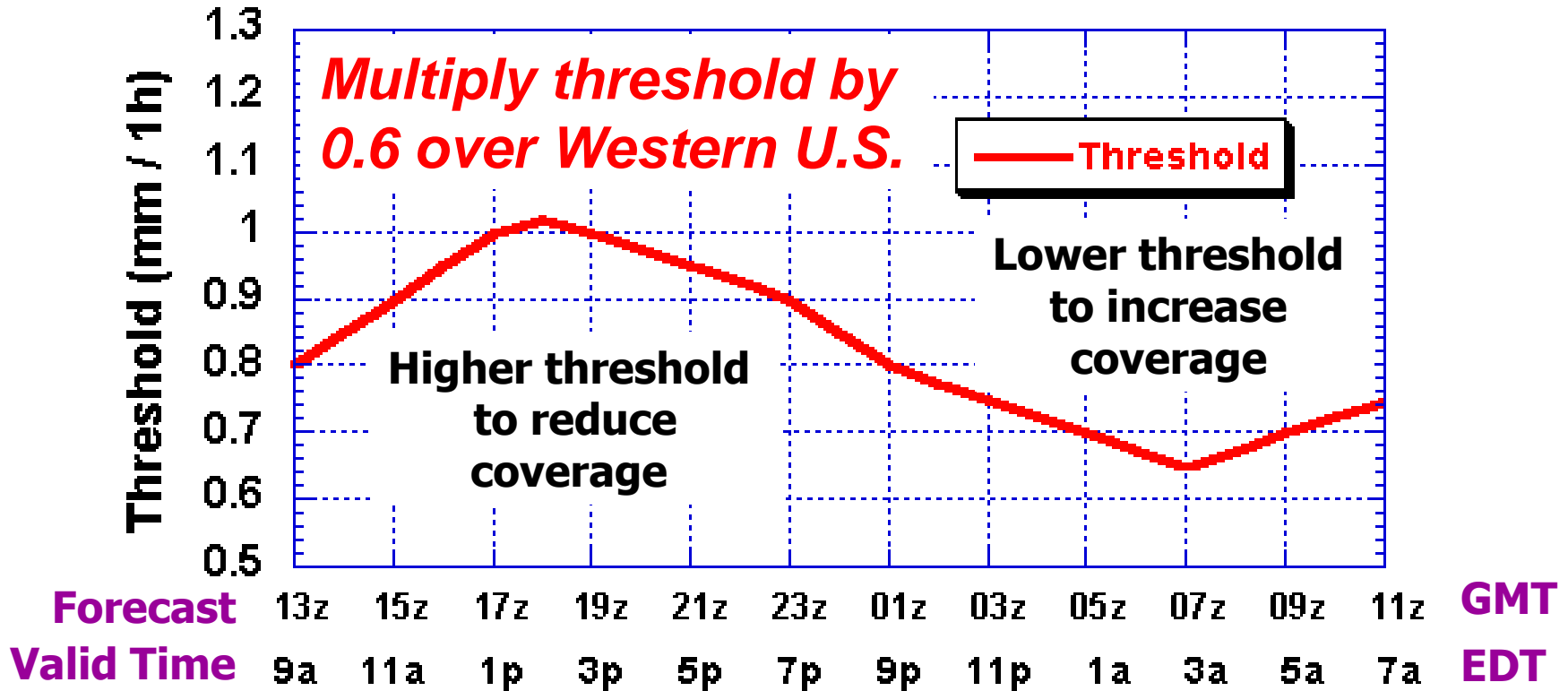
HRRR reflectivity

Hrly max HRRR refl

Hrly max updraft

Bias corrections

RUC 1-h convective precipitation threshold

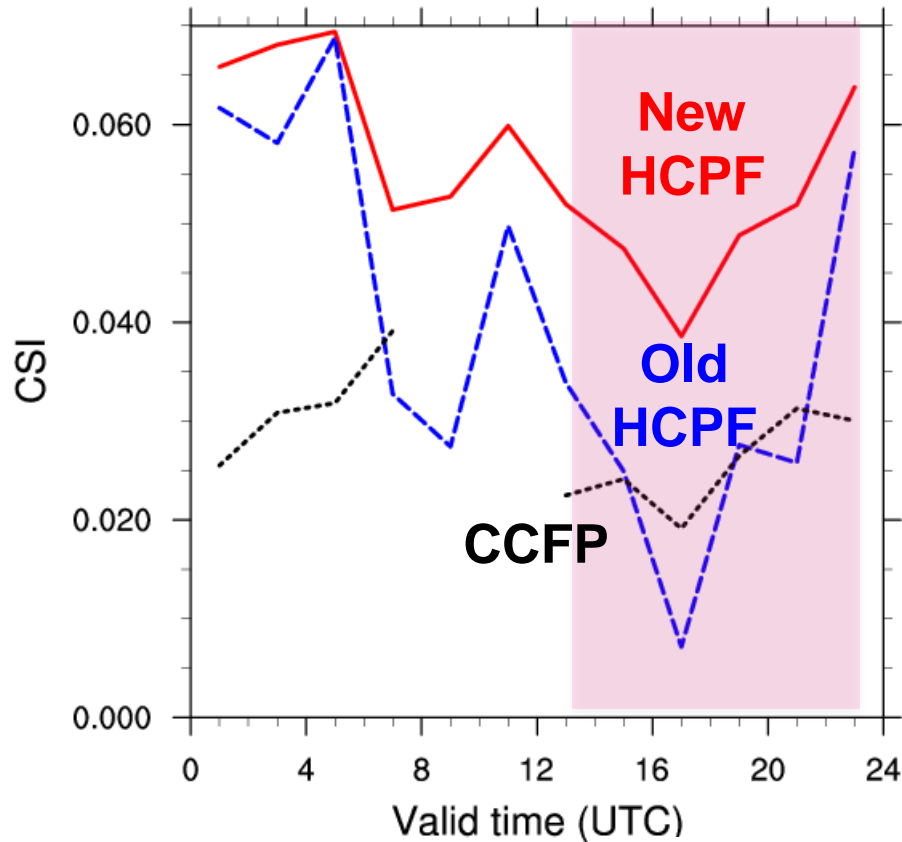


- Precipitation threshold adjusted **diurnally** and **regionally** to optimize the forecast bias
- Use **smaller filter** length-scale in **Western U.S.**

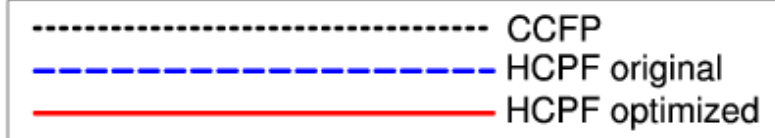
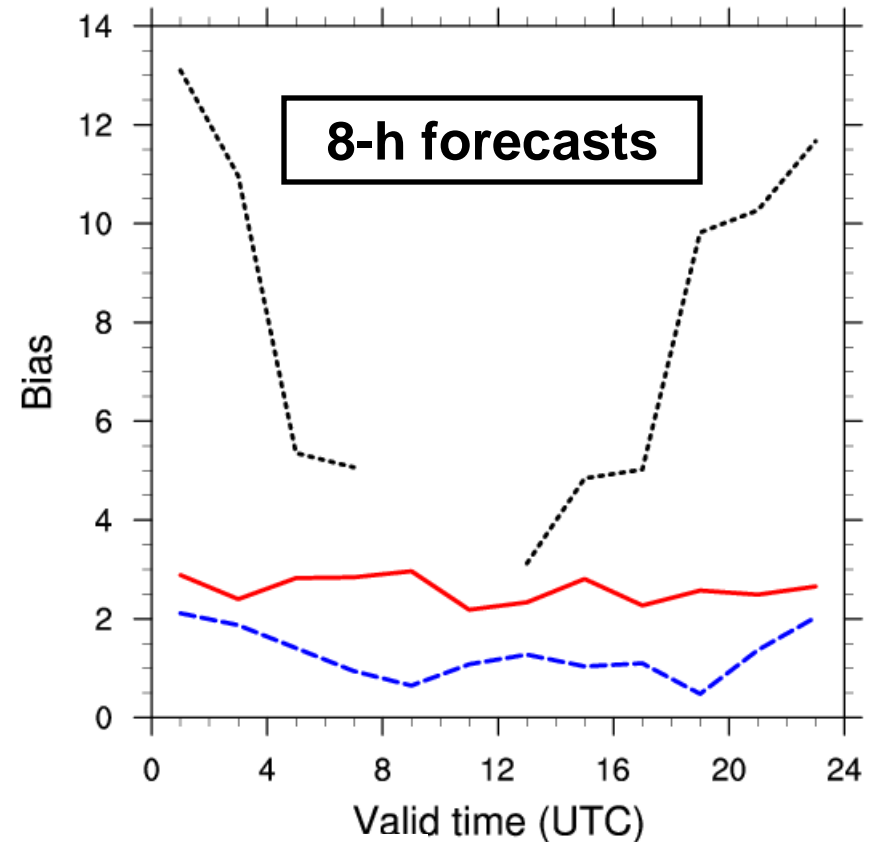
HCPF improvement from optimizing parameters

- switch predictors
- use diurnal threshold selection
- reduce time-lag
- optimize spatial filter size

CSI as a function of valid time (6/18/09 - 6/29/09)



Bias as a function of valid time (6/18/09 - 6/29/09)



HCPF example

HRRR

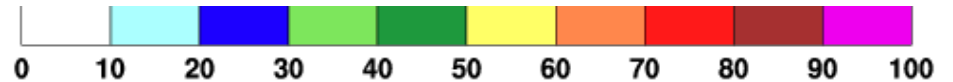
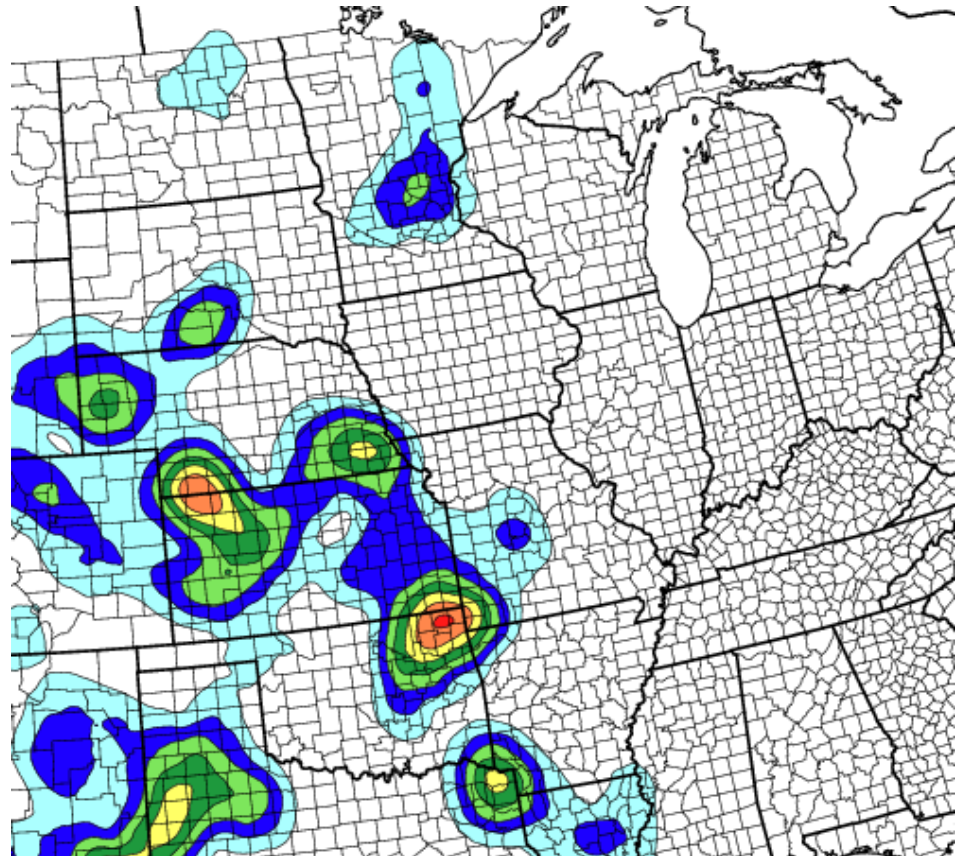
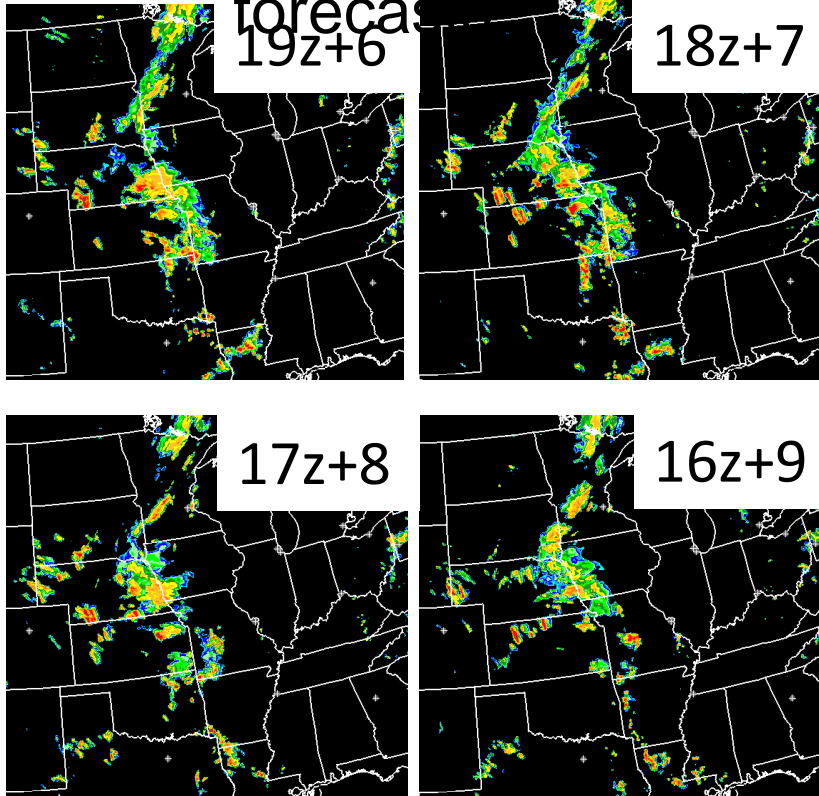
forecast
19z+6

18z+7

17z+8

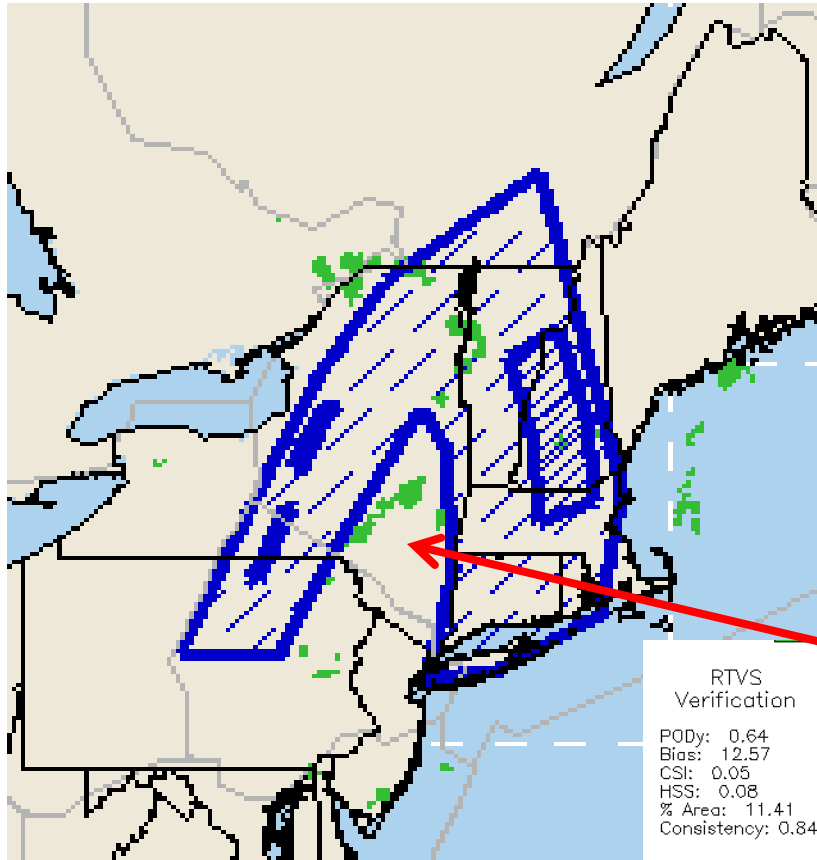
16z+9

HCPF (4-hour lead)

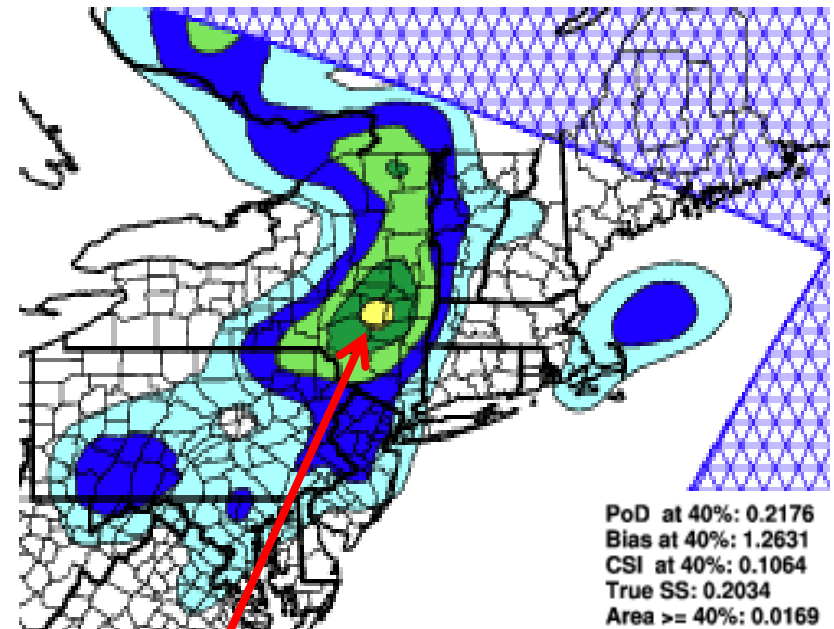


16 July 2009 case study

17z + 4 hour CCFP:

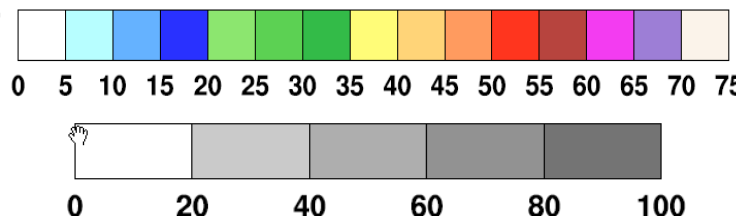


15z + 6 hour HCFP:



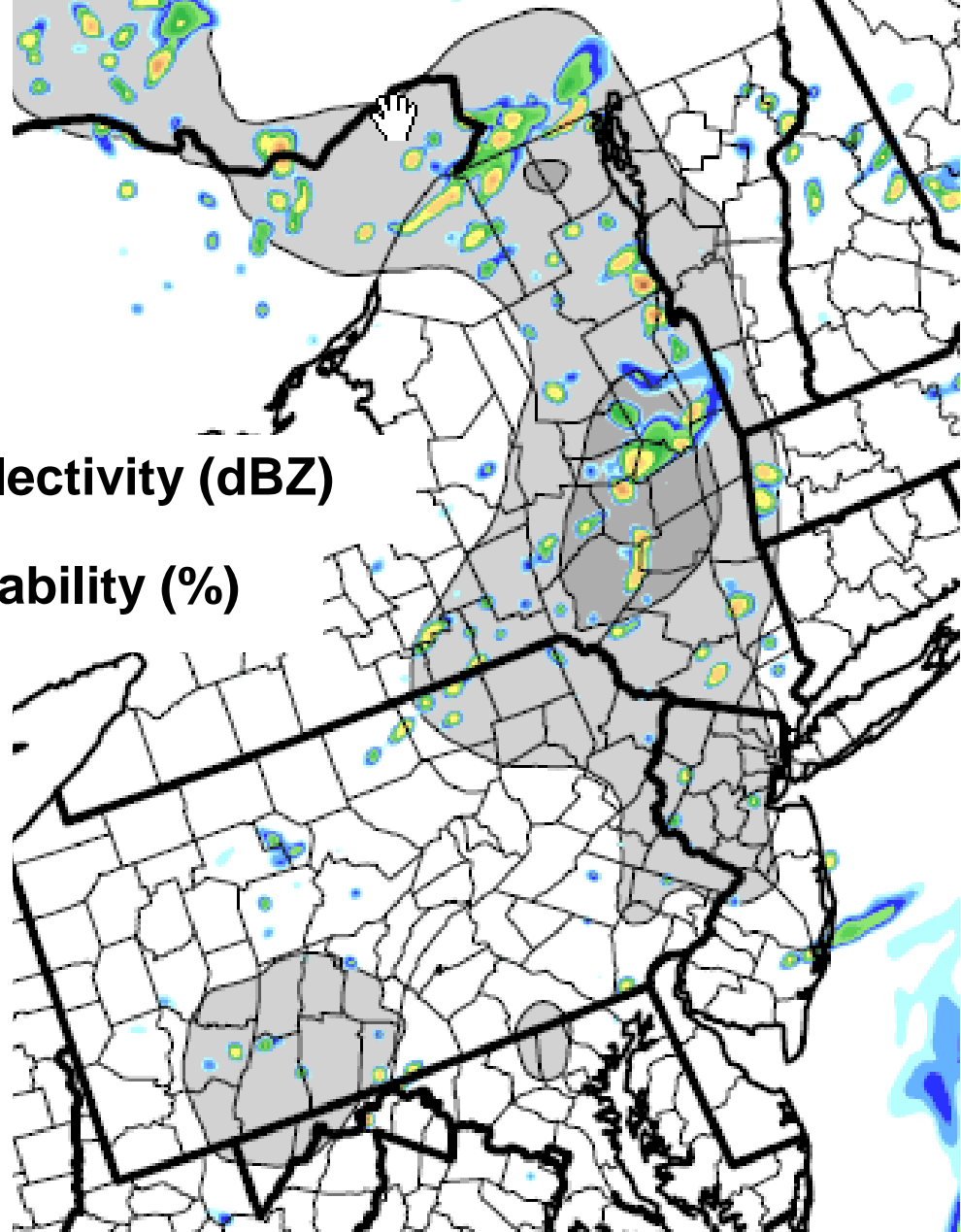
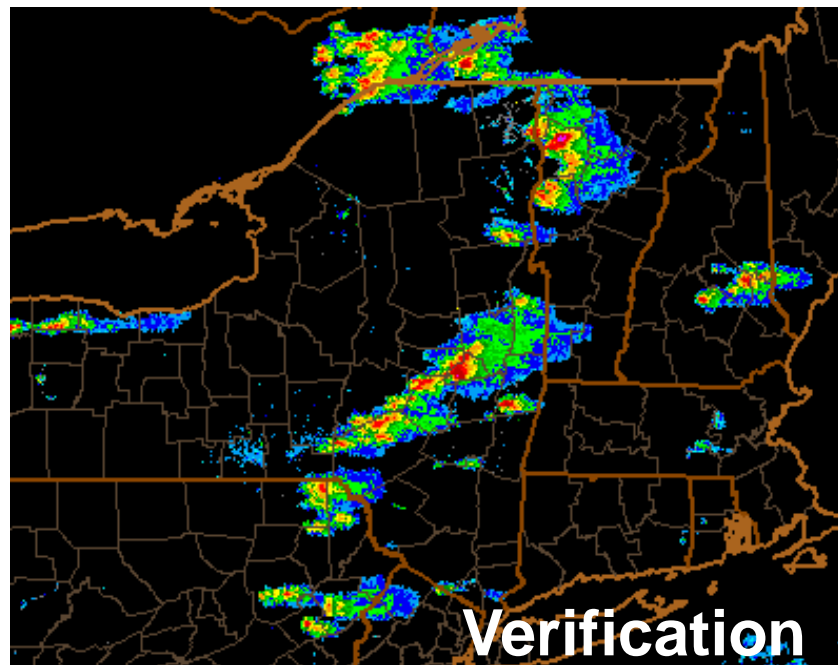
HCFP accurately placed a bulls eye over east-central NY
CCFP missed this cluster of storms

July 16, 2009 HCPF / HRRR overlay



Reflectivity (dBZ)

Probability (%)



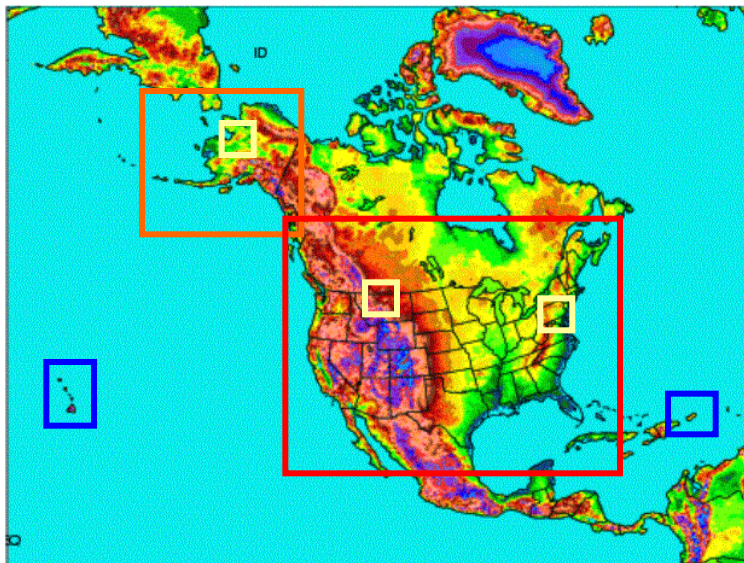
15z + 6h HRRR and HCPF

Planned NCEP Operation

Meso- and Storm-scale models

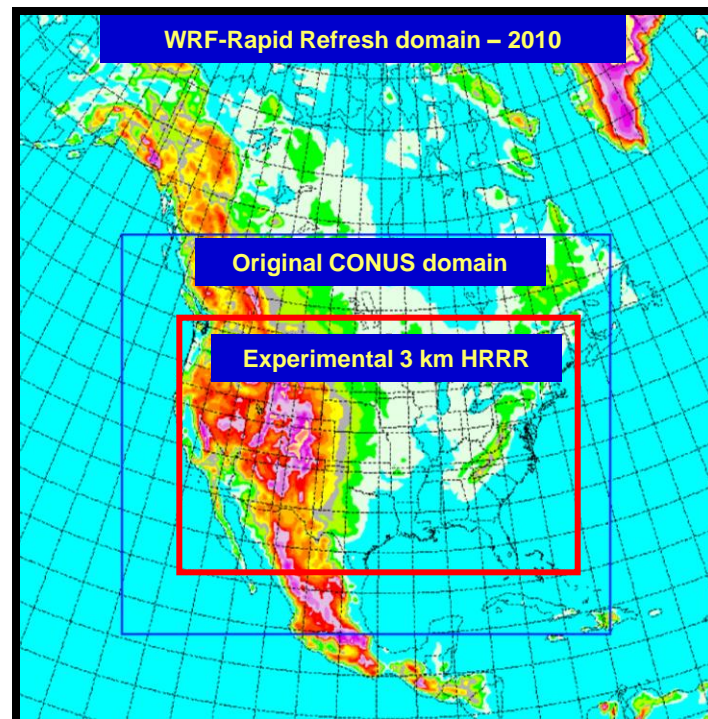
NAM 2010-2011

- NEMS based NMM
- Bgrid replaces Egrid
- Parent remains at 12 km
- Multiple Nests Run to 48hr
 - ~4 km CONUS nest
 - ~6 km Alaska nest
 - ~3 km HI & PR nests, and/or a ~1.5-2km DHS/FireWeather/IMET are possible



Rapid Refresh

- WRF-based ARW
- NCEP's GSI analysis (RR-version)
- Expanded 13 km Domain to include Alaska
- **Experimental 3 km HRRR @ ESRL**



Planned Operational Meso- and Storm-scale Ensembles

2012-2013

NAM/Rapid Refresh ENSEMBLE – NRRE

- Initially ~6 member ensemble made up of equal numbers of NMMB- & ARW-based configurations
- Hourly updated with forecasts to 24 hours

High Res Rapid Refresh ENSEMBLE – HRRRE

- Nest HRRRE ensemble within NRRE
- Opportunities to:
 - Provide improved probability guidance for hazardous wx
 - Use for Nextgen, Warn-on-Forecast, sensible wx

Very Short-Range Ensemble Forecasts - VSREF

- Updated hourly w/ available members valid at same time

VSREF members

2010 hourly RR at NCEP –

- hourly time-lagged (TL) ensemble members possible
- ESRL 3km HRRR (TL ensemble)

2012 – NRRE ensemble at NCEP

- (from RR ARW and NMM)
- proposed HRRR at NCEP
 - future HRRRE from NRRE

GFS / GFS ensemble

SREF (updated every 6h)

**VSREF –
Hourly
Updated
Probabilistic
Forecasts
= TL+
ensemble**

Time-lagged ensemble provides skill baseline for evaluating HRRRE and NARRE development

VSREF-

Model Ensemble Members
- hourly ($\leq 1h$) updated

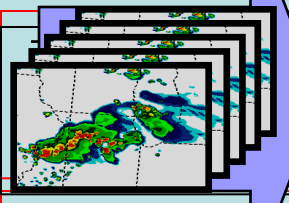
Unified Post-processing Algorithms (modularized!!)

for following: (multiple where appropriate), built on current WRFpost from NCEP

VISION: Toward estimating and reducing forecast uncertainty for aviation applications using high-frequency data assimilation

- Turb (e.g., GTG)
- Icing (e.g., FIP)**
- Ceiling
- Visibility
- Convection
- ATM route options
- Wake vortex
- Terminal forecast
- Object diagnosis (line convection, clusters, embedded)
- Others...

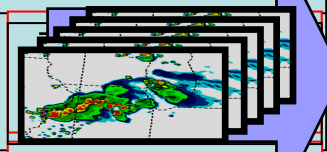
VSREF mems output for each AIV variable



For icing

Stat correction post-processing using recent obs

VSREF mems output - stat corrected



For icing

Optimal weighting

Most-likely-estimate single value

Probability/PDF output

VSREF members - HRRR, RR, NAM, SREF, GFS, etc.

Explicit met variables from each VSREF member - V,T,qv,q* (hydrometeors),p/z, land-surface, chem, etc.

Potentially multiple variables under each Avx-Impact-Var (AIV) area

Ongoing / Future areas for Collaboration

Model / analysis improvement

- Code management(GSI), controlled testing, community input

Real-time deterministic system analysis

- Retro and real-time evaluations -- newer verification methods
- “Field” testing and feedback on real-time systems
 - resolution, DA methods / obs usage, lead-time issues, etc.

Real-time ensemble configuration analysis

- Assessment of many parameters (input models, perturbation methods, LBC issues, feature extraction, blending with obs)
- **Maintenance of ensemble model database**

Multiple application areas (much overlap!)

- Nextgen – enroute and terminal (convection, other hazards)
- Warn on Forecast – strategic and tactical guidance
- Sensible weather prediction (NDFD, etc.)