NCEP Production Suite Review
4 -5 December 2012

Hourly updated models:
Rapid Refresh / HRRR review

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Major topics

Rapid Refresh

- **Initial version implemented May 1, 2012**
- Real-time version 2 ("V2") producing significant improvement over RAP V1 **(better mid-level moisture, convective boundary layer, and near-surface fields)**
- Further enhancements for V2: **(Hybrid DA from global ensemble DA)**

High Resolution Rapid Refresh

- Two real-time experimental versions, (Jet, Zeus) each with > 90% run reliability
- Significant improvement in 2012 compared to 2011 from RAP v2 enhancements
- Experimental 3-km, 15-min cycled radar DA

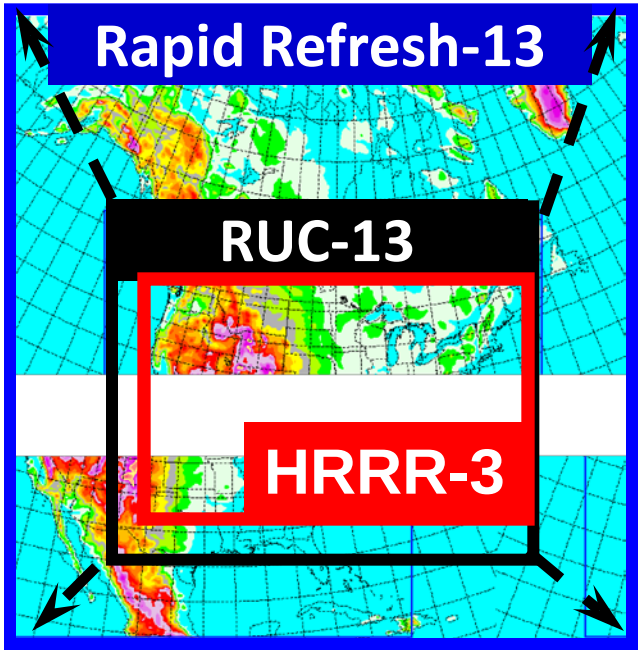
Rapid Refresh and HRRR
NOAA hourly updated models

NCEP RUC → Rapid Refresh (01 May 2012)

— Advanced community codes (ARW and GSI)

— Retain key features from RUC analysis / model system
(hourly cycle -- radar DFI assimilation -- cloud analysis)

— **RAP short-range guidance for aviation, severe weather, energy applications**



GSD Rapid Refresh v2

— **Many improvements, target NCEP implement early 2013?**

GSD HRRR

– **Runs as nest within RAP v2**

RUC to Rapid Refresh transition

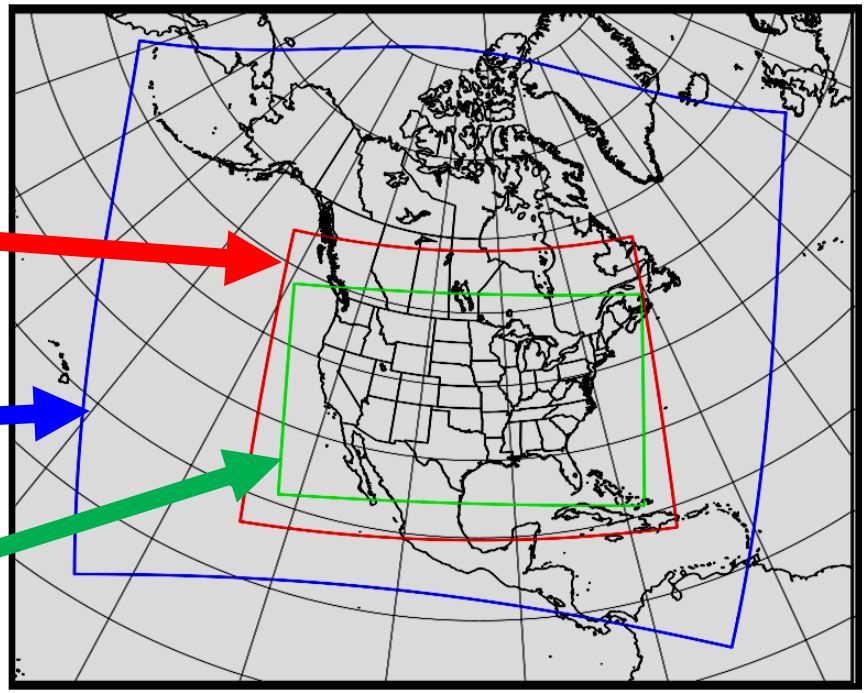
- CONUS domain → North American domain
- RUC Model → WRF-ARW Model
- RUC 3dvar → GSI – Gridpoint Statistical Interpolation
- RUC post → Unipost

Hourly updated models

13km RUC

13km Rapid Refresh

3km HRRR



WRF-ARW / GSI enhancements for RAP

- **GSD contributions to WRF-ARW**
  - Grell 3-D cumulus scheme
  - RUC (Smirnova) Land Surface Model
  - Diabatic Digital Filter (with NCAR)
  - DFI-radar reflectivity assimilation
- **GSD contributions to GSI**
  - Non-variational cloud analysis
  - Ingest for cloud / hydrometeor fields / obs
  - Enhancements to surface obs assimilation

RUC → RAP / HRRR configuration

Community-based advanced model and analysis

- **WRF-ARW:** advanced numerics, non-hydrostatic
- **GSI:** advanced satellite data assimilation

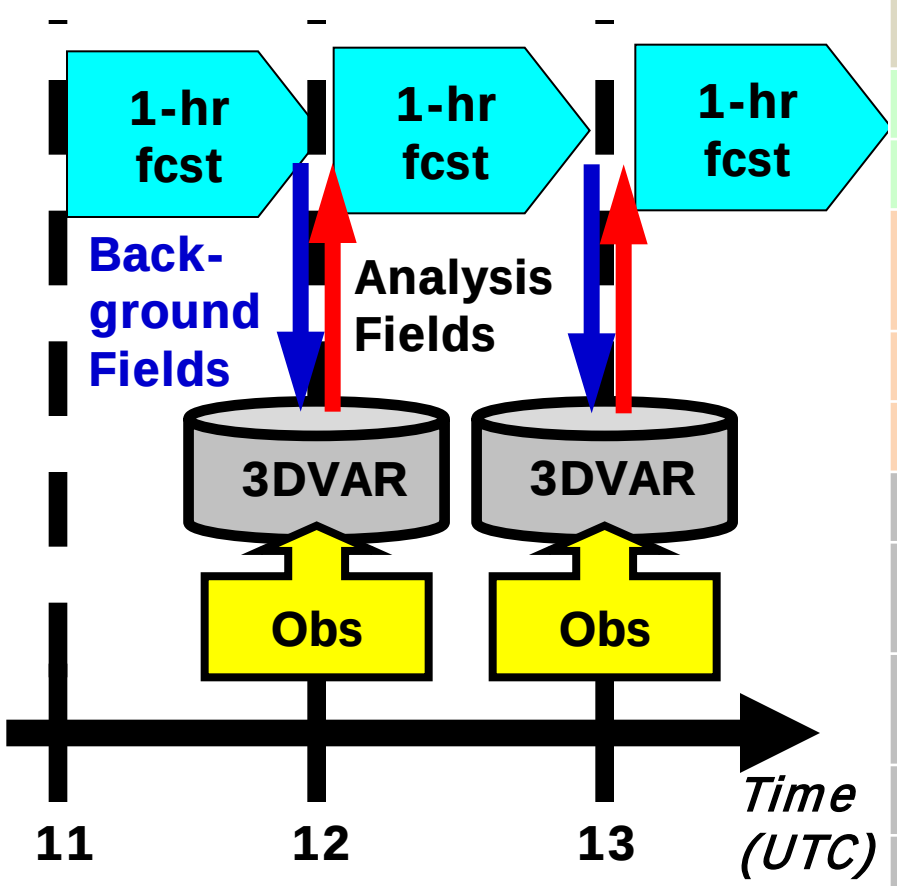
Model	Run at:	Domain	Grid Points	Grid Spacing	Vertical Levels	Pressure Top	Boundary Conditions	Initialized
RUC	GSD	CONUS	451 x 337	13-km	50	Sigma/ Isentropic	NAM	Hourly (cycle)
RAP	NCO GSD	North America	758 x 567	13 km	50	10 mb	GFS	Hourly (Part. cycle)
HRRR	GSD	CONUS	1799 x 1059	3 km	50	20 mb	RAP	Hourly - RAP (no-cycle)

Model	Assimilation	Cloud Analysis	Radar DFI	Radiation	Microphysics	Cum Param	PBL	LSM
RUC	RUC-3DVAR	Yes	Yes	RRTM / Dudhia	Thompson (2003)	Grell-Devenyi	Burk – Thompson	RUC 2003
RAP	GSI-3DVAR	Yes	Yes	RRTM/ Goddard	Thompson	G3 + Shallow	MYJ	RUC 2010
HRRR	None: RAP I.C	No	No	RRTM/ Dudhia	Thompson	None	MYJ	RUC 2010

Rapid Refresh
Hourly Update Cycle

Partial cycle atmospheric fields – introduce GFS information 2x/day

Fully cycle all land-sfc fields

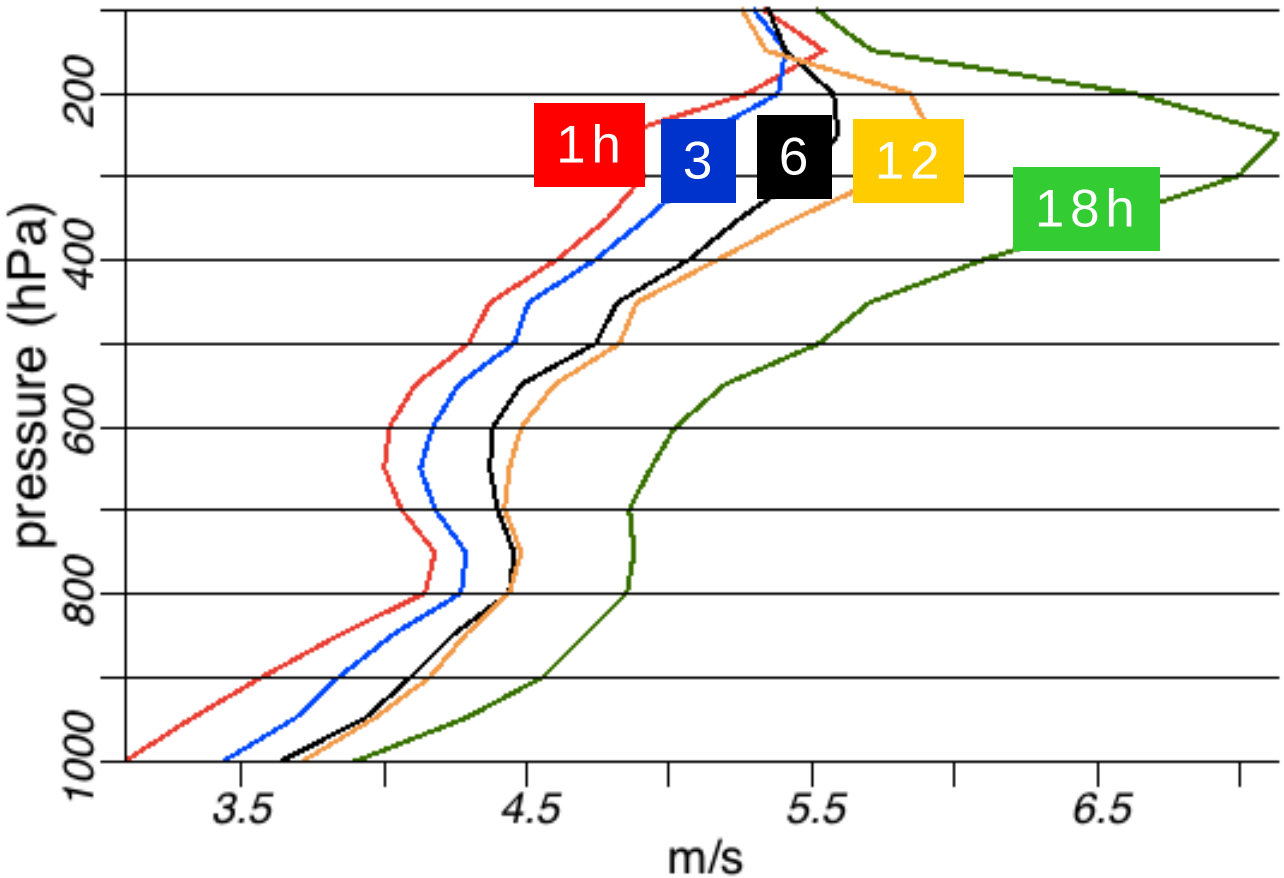


Hourly Observations	RAP 2012 N. Amer
Rawinsonde (T,V,RH)	120
Profiler – NOAA Network (V)	21
Profiler – 915 MHz (V, Tv)	25
Radar – VAD (V)	125
Radar reflectivity - CONUS	2km
Lightning (proxy reflectivity)	NLDN, GLD360
Aircraft (V,T)	2-15K
Aircraft - WVSS (RH)	0-800
Surface/METAR (T,Td,V,ps,cloud, vis, wx)	2200- 2500
Buoys/ships (V, ps)	200-400
Mesonet (T, Td, V, ps)	flagged
GOES AMVs (V)	2000- 4000
AMSU/HIRS/MHS radiances	Used
GOES cloud-top pressure/temp	13km
GPS – Precipitable water	
WindSat scatterometer	2-10K

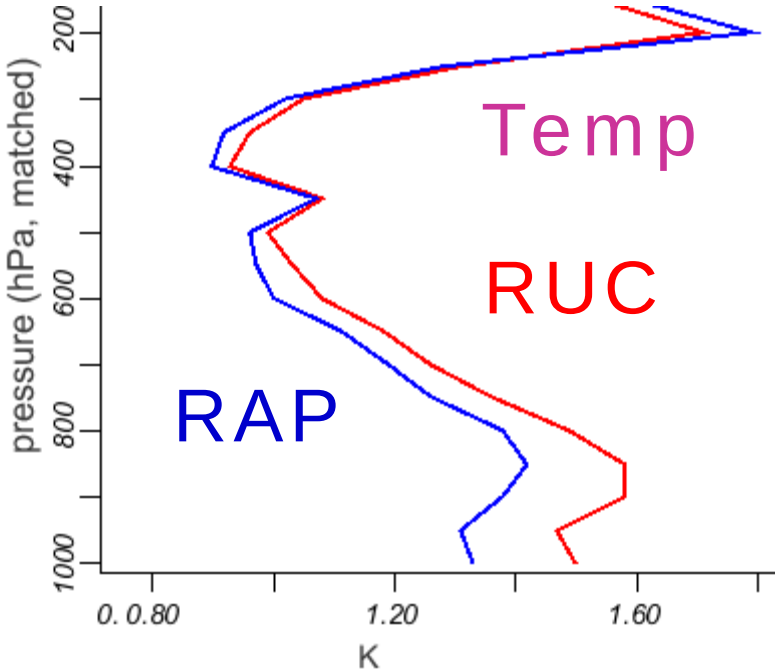
RAP error reduction to 1-h forecast

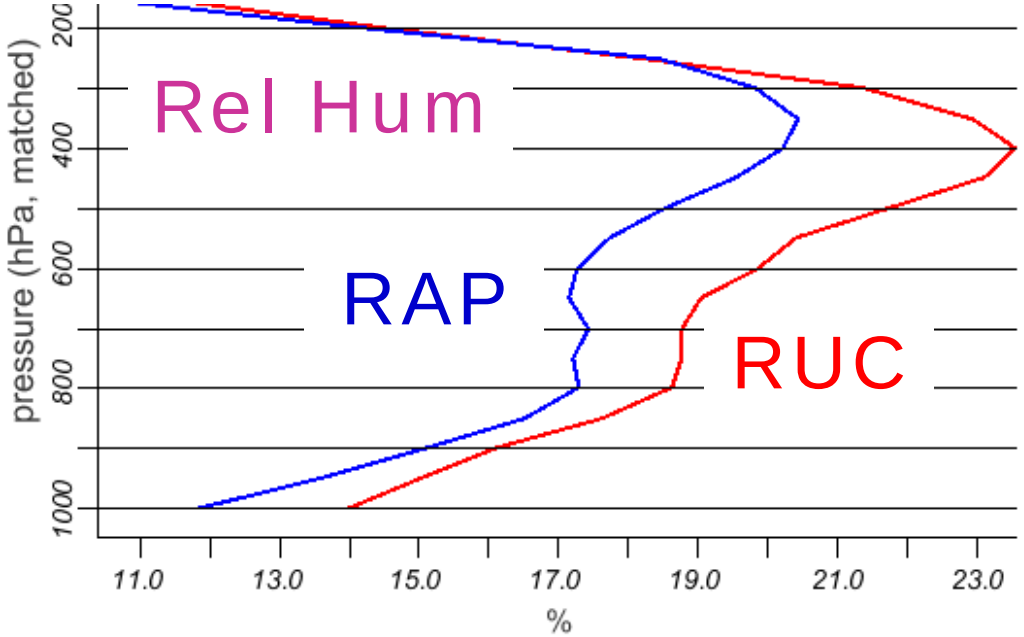
Rapid Refresh
Wind forecast accuracy vs. forecast length

1 Jan -
7 Mar 2012
- Verification against raobs



The Rapid Refresh is able to use recent obs to improve forecast skill down to 1-h projection





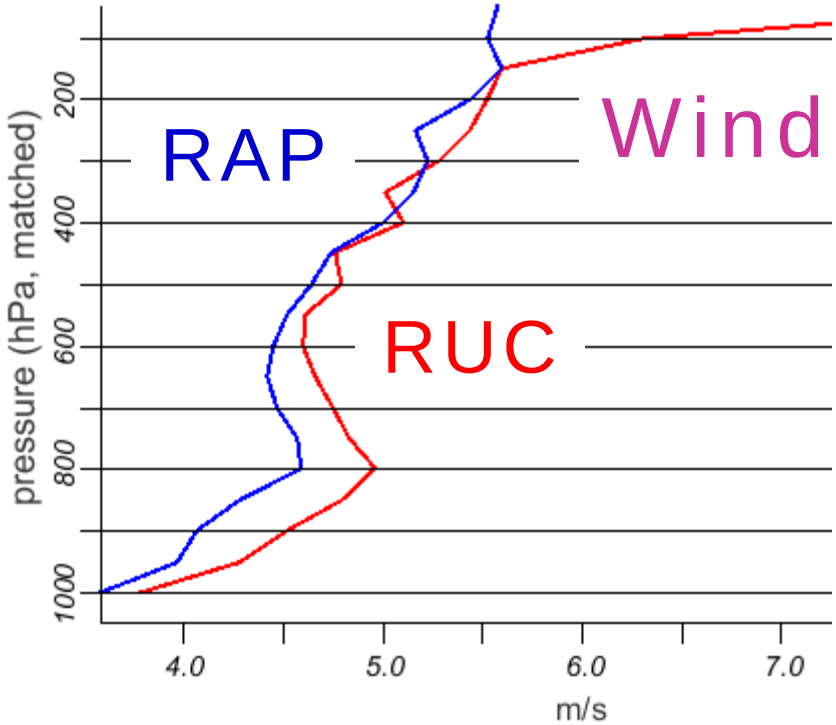
RUC vs. RAP

upper-air verification

+ 3h forecast

RMS Error

15 Feb 2012 – 8 March 2012

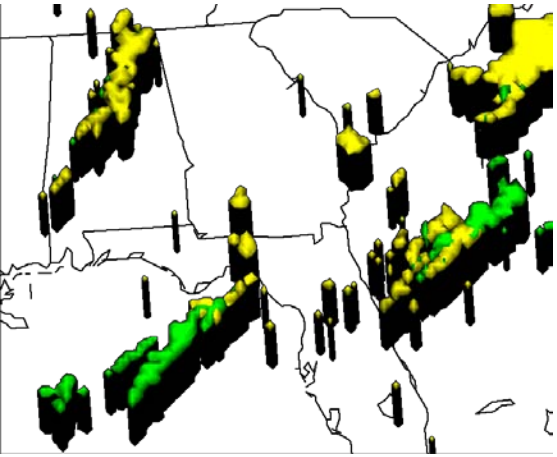


Radar reflectivity assimilation

Digital filter-based reflectivity assimilation initializes ongoing precipitation regions

-20 min | -10 min | Initial | +10 min | + 20 min

Backwards integration, no physics



Forward integration,full physics with radar-based latent heating

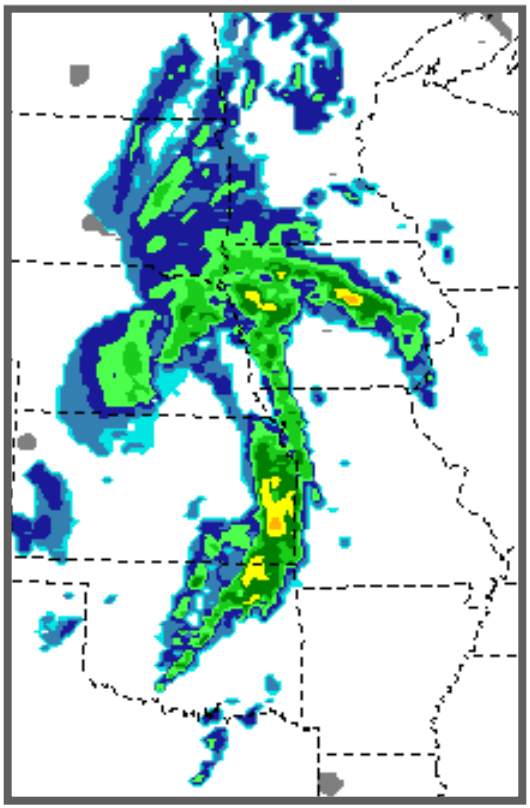
Initial fields with improved balance, storm-scale circulation

RUC / RAP HRRR model forecast

+ RUC/RAP Convection suppression

Rapid Refresh (GSI + ARW)
reflectivity assimilation example

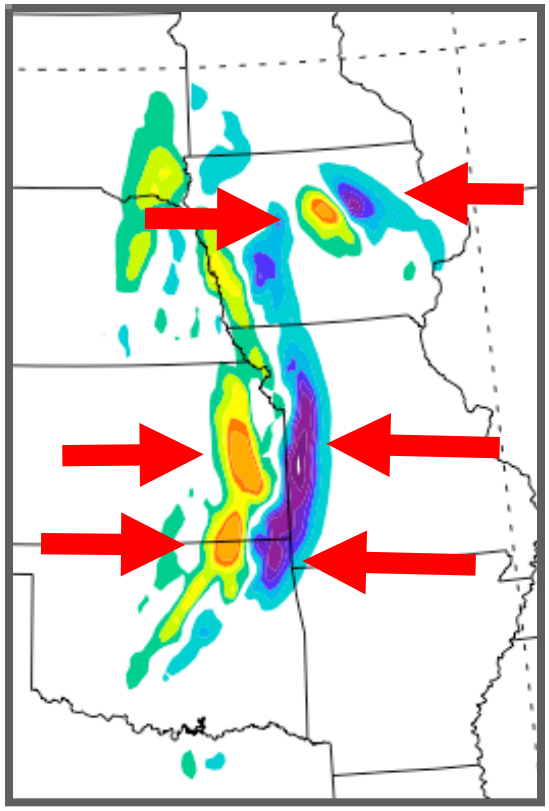
NSSL radar reflectivity (dBZ)



14z 22 Oct 2008

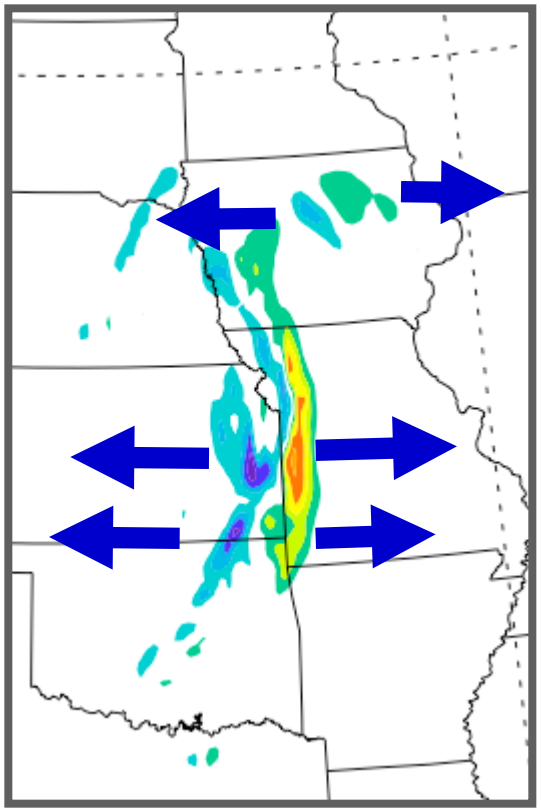
Z = 3 km

Low-level Convergence

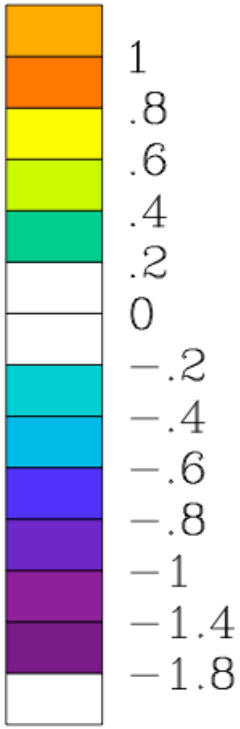


K=4 U-comp. diff (radar - norad)

Upper-level Divergence

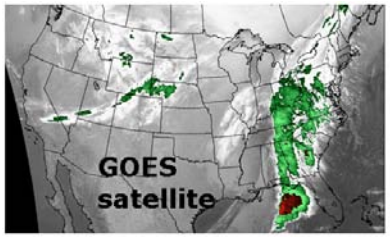


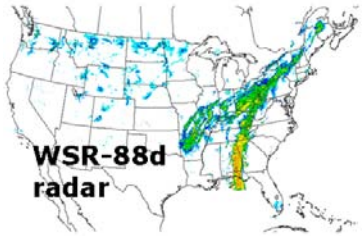
K=17 U-comp. diff (radar - norad)

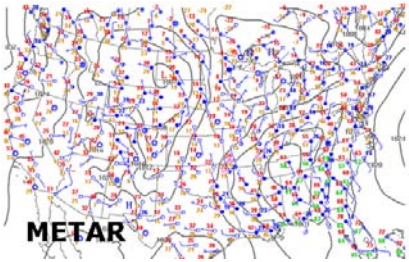


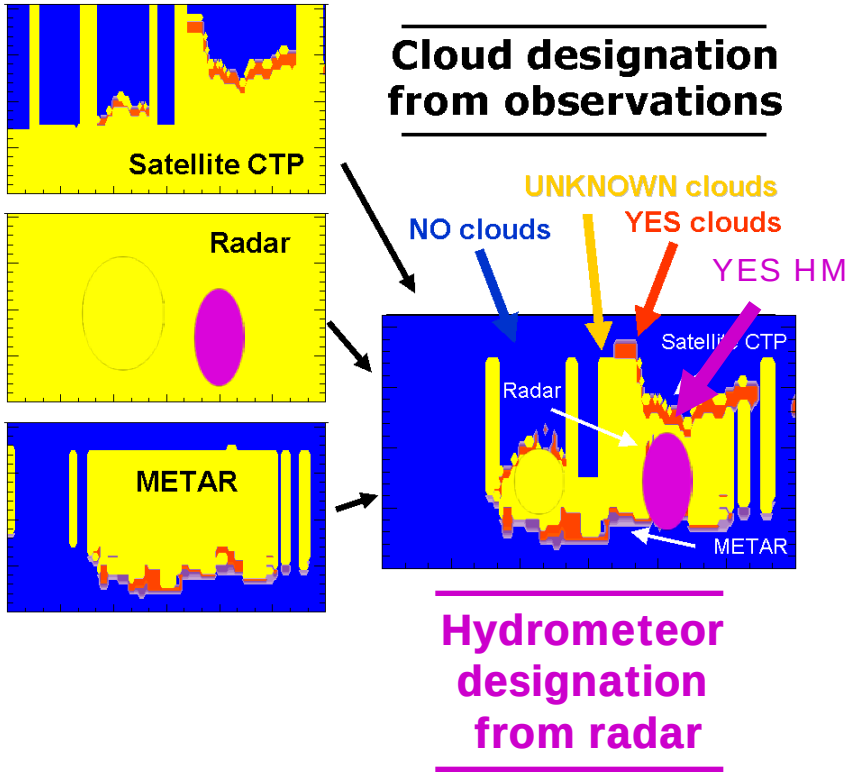
Cloud and hydrometeor analysis

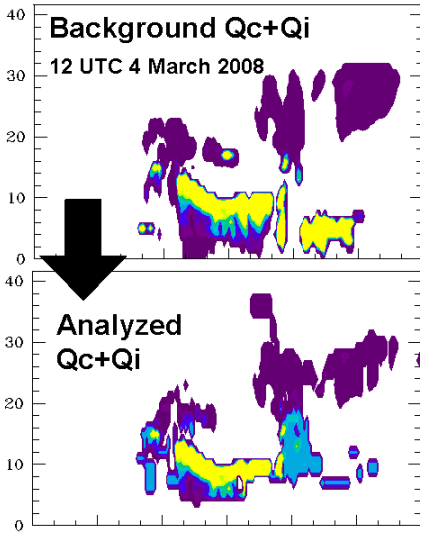
Adjust cycled explicit cloud fields using METAR and satellite data











RAP vs. RUC Precipitation Verification

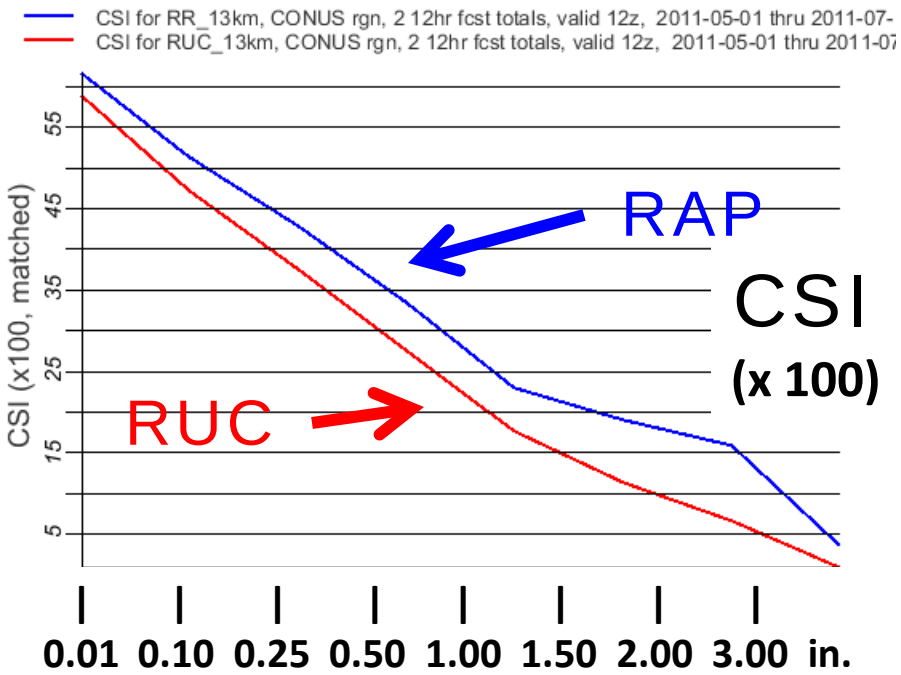
13-km CONUS

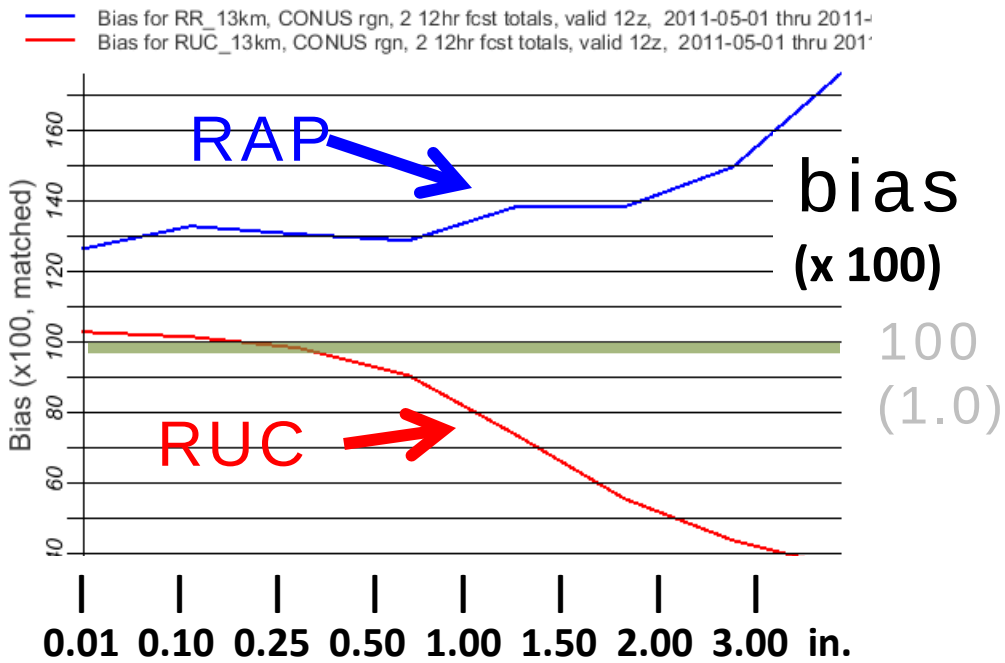
Comparison

2 X 12 hr fcst
vs. CPC 24-h analysis

1 May – 15 July 2011
Matched

SPRING/
SUMMER

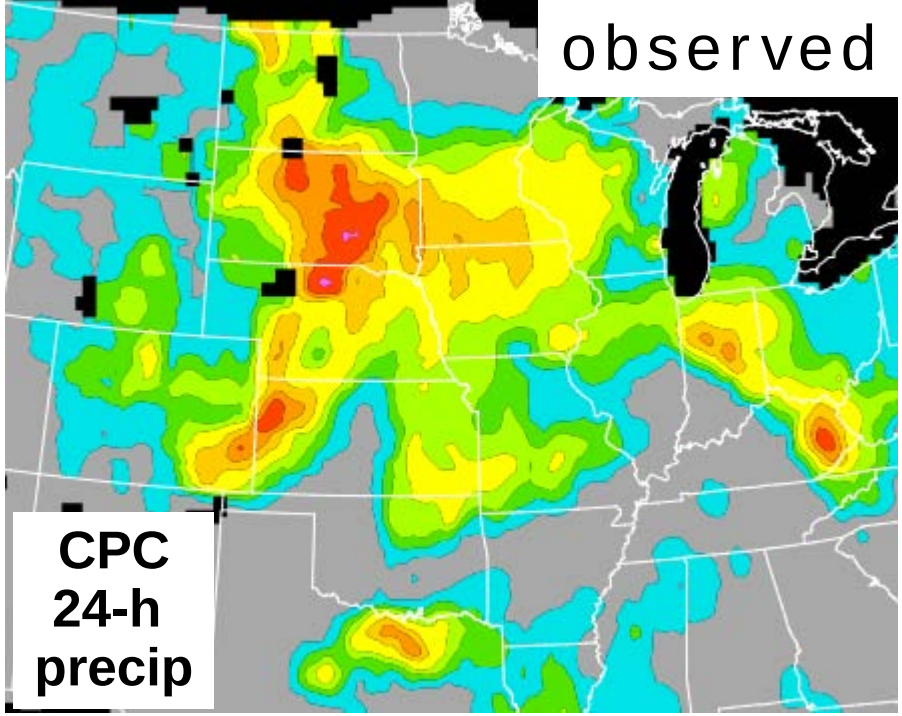


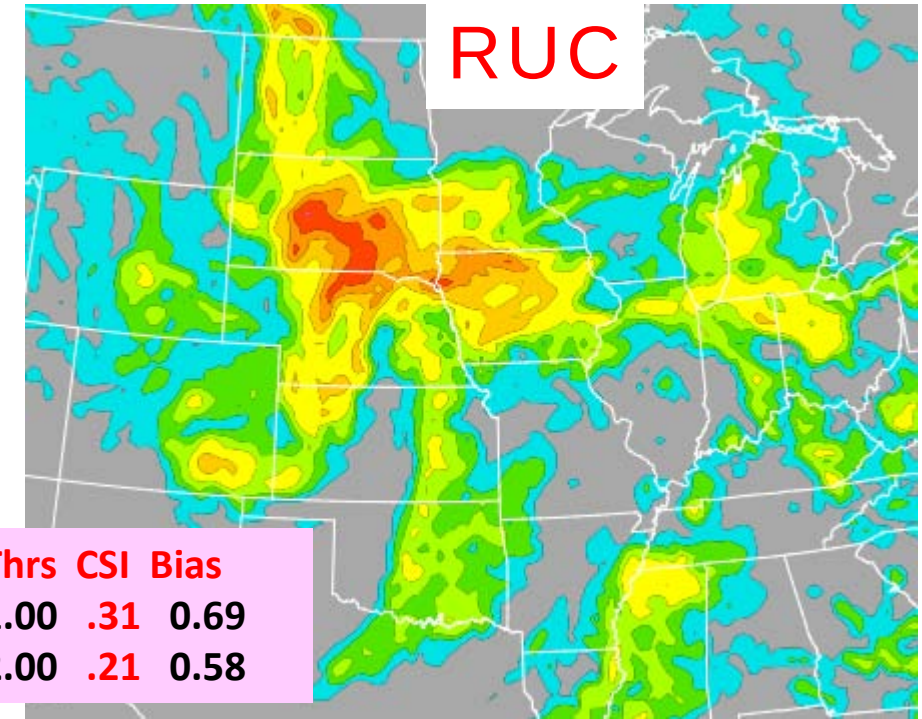


RAP vs. RUC 24-h precip. verif

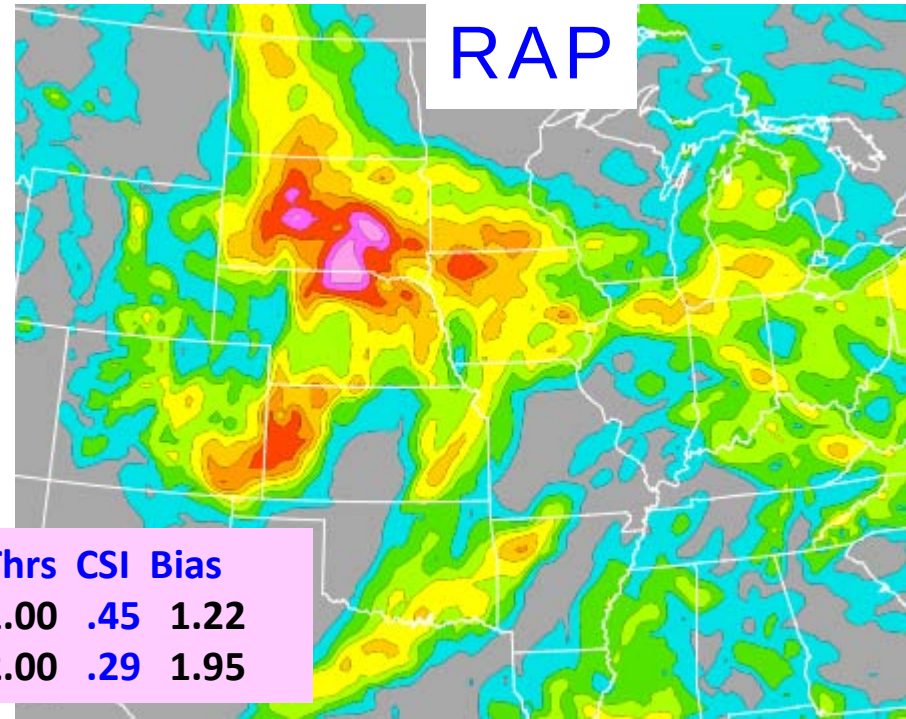
2 x 12h fcst ending 12z 21 June 2011

Interpolated to 20-km grid





Thrs	CSI	Bias
1.00	.31	0.69
2.00	.21	0.58

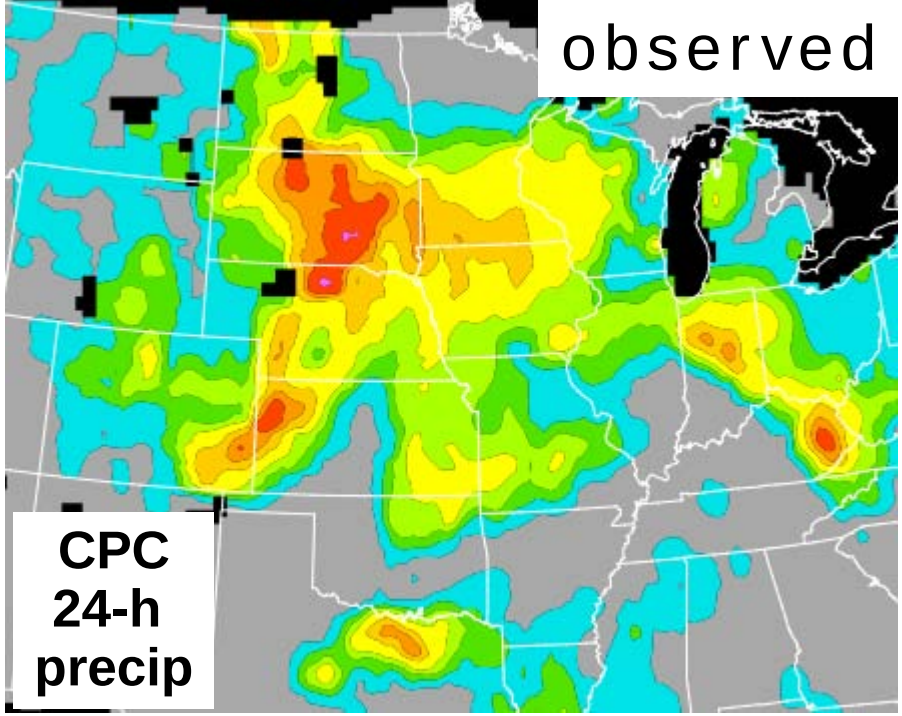


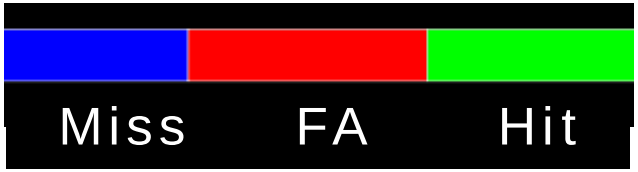
Thrs	CSI	Bias
1.00	.45	1.22
2.00	.29	1.95

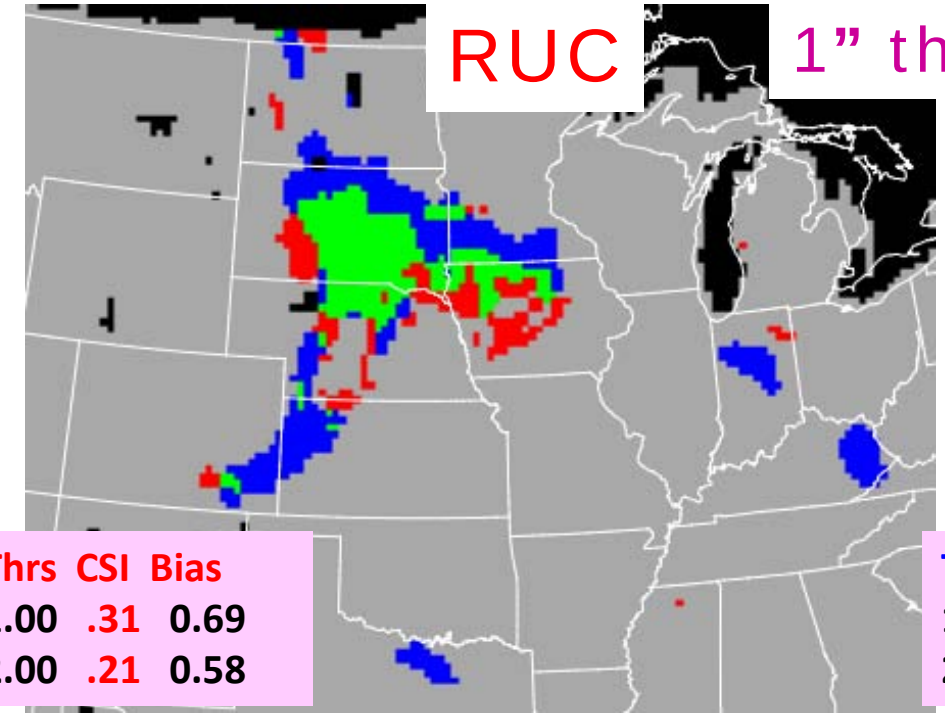
RAP
vs.
RUC
24-h
precip.
verif

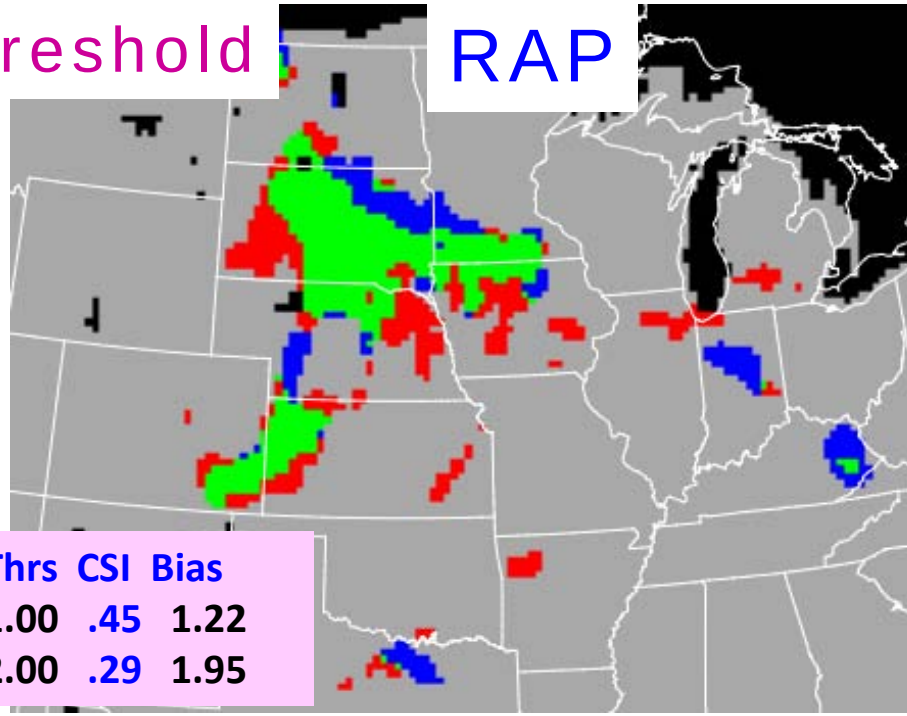
2 x 12h fcst
ending 12z
21 June 2011

Interpolated
to 20-km grid





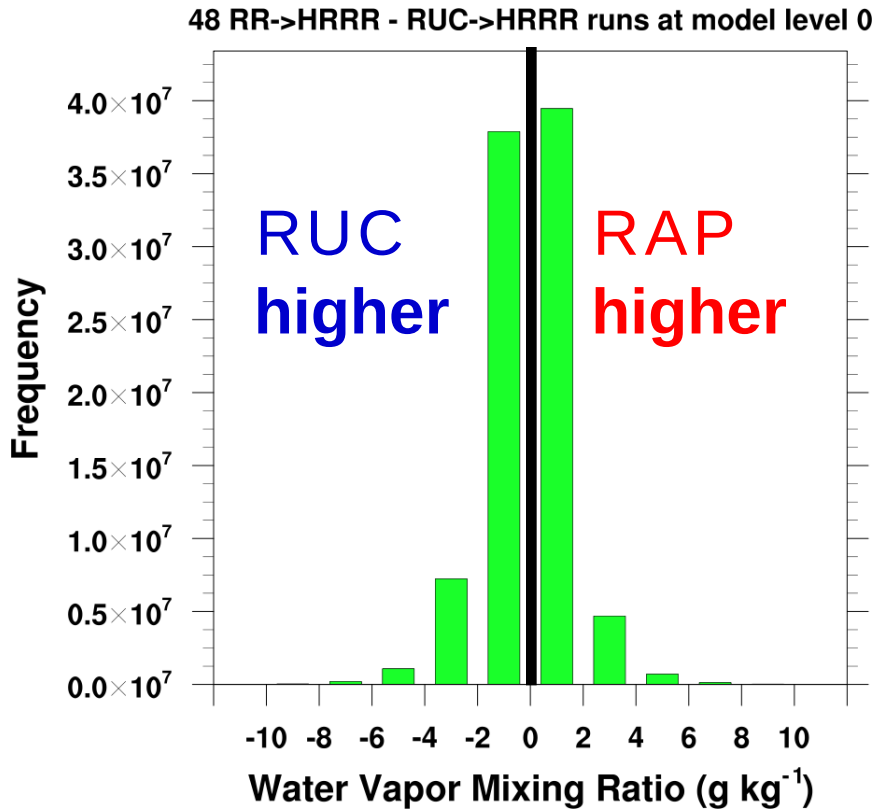




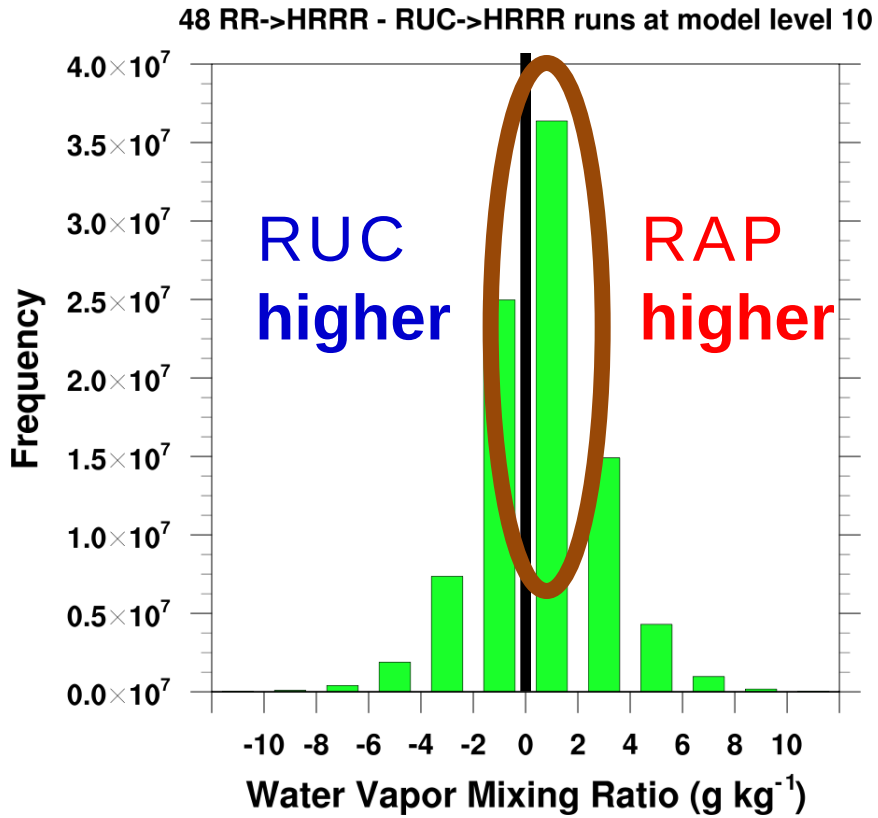
RAP vs. RUC 0-hour water vapor histograms

CONUS 11-22 August 2011

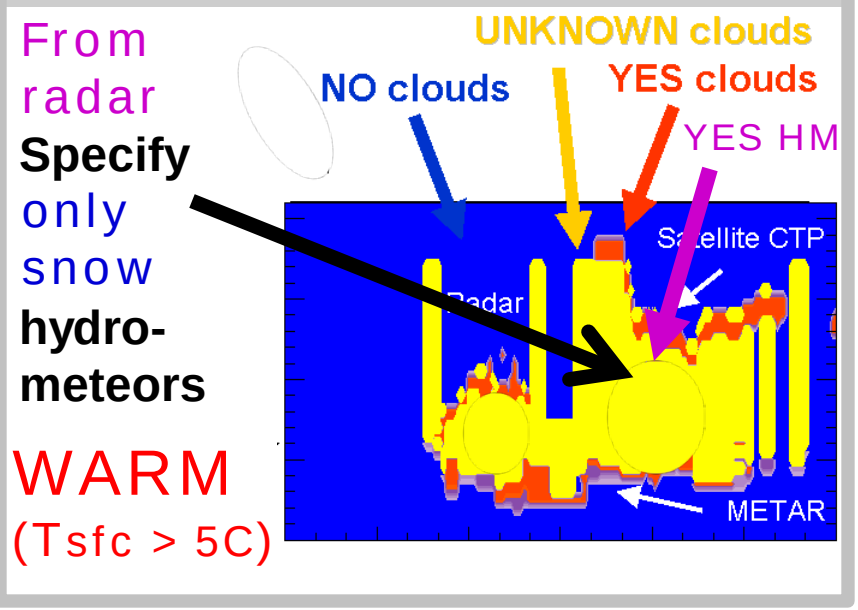
Surface



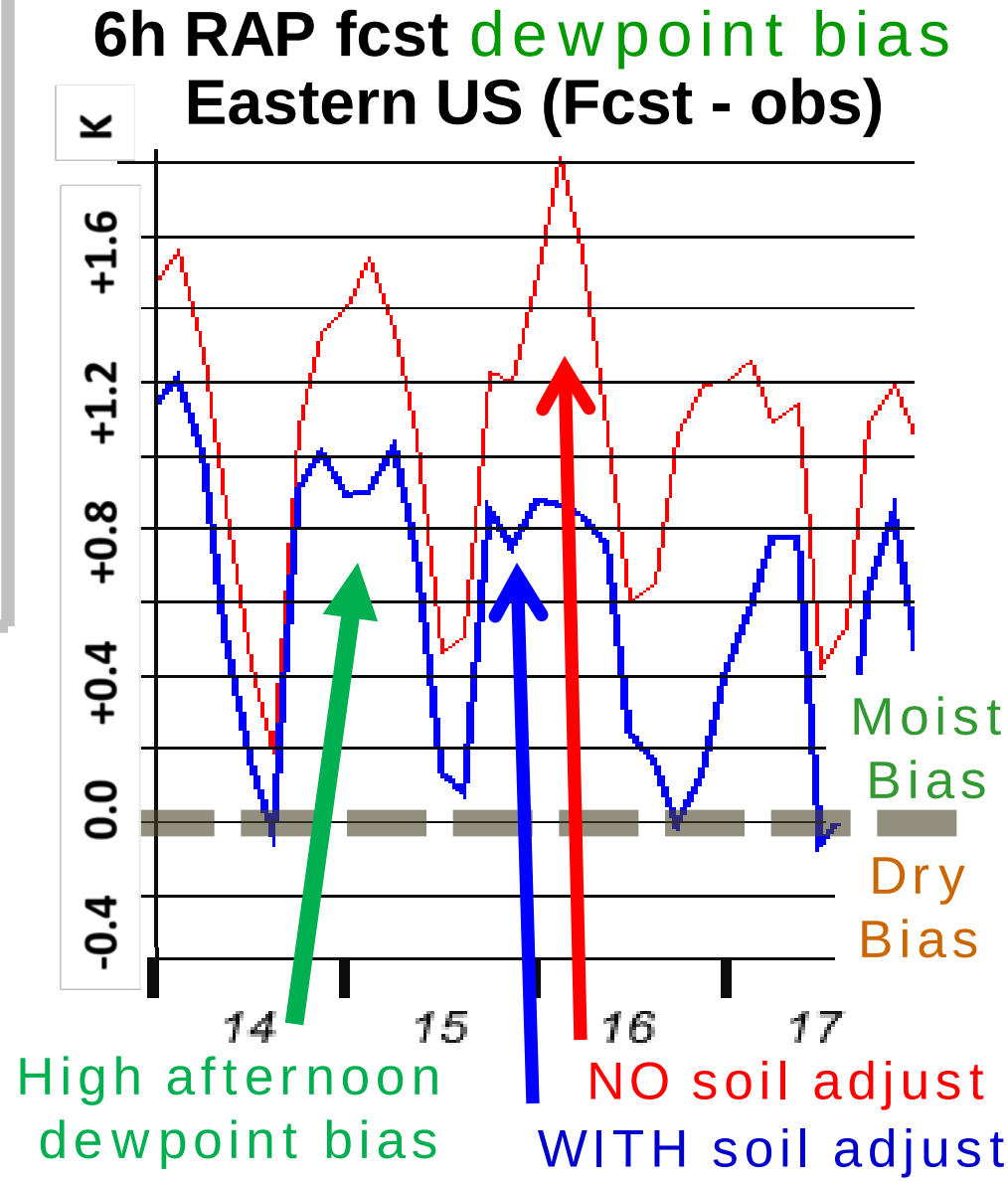
~800 mb



Temp. dependent hydrometeor specification



RAP soil adjustment from surface obs



Soil adjust (T'_{soil} , Q'_{soil})

Q'_{soil} applied if:

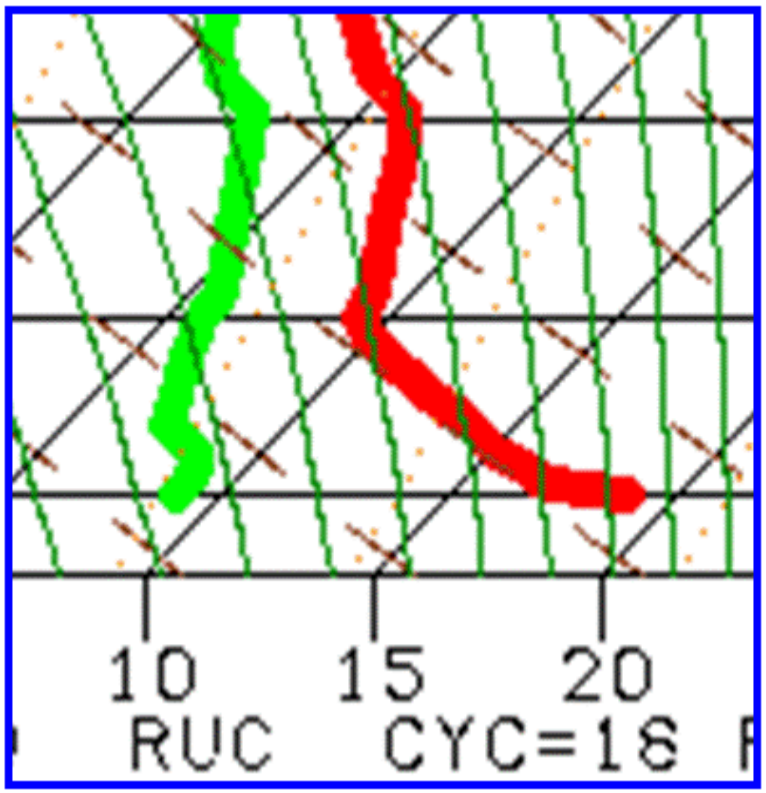
- ***-- T'(k=1) q'(k=1) opp. sign***
- ***-- Daytime, No clouds***
- ***-- Proportional to q'(k=1)***

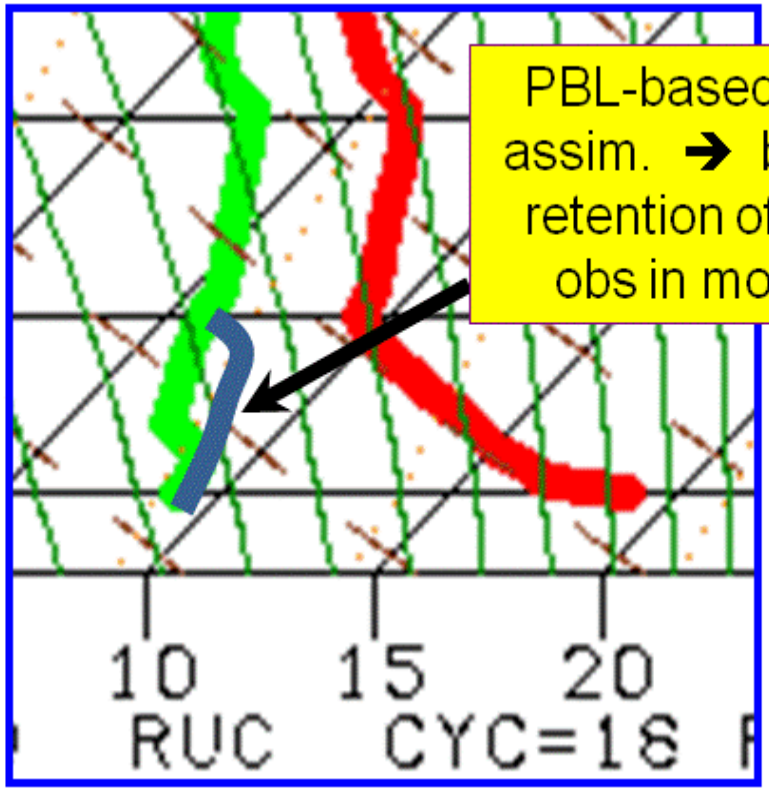
Assume – Bowen ratio error from soil Q' error

Apply top 2 LSM levels

Assimilate Surface dewpoint pseudo-observations

→ Create moisture pseudo-observations through depth of mixed BL

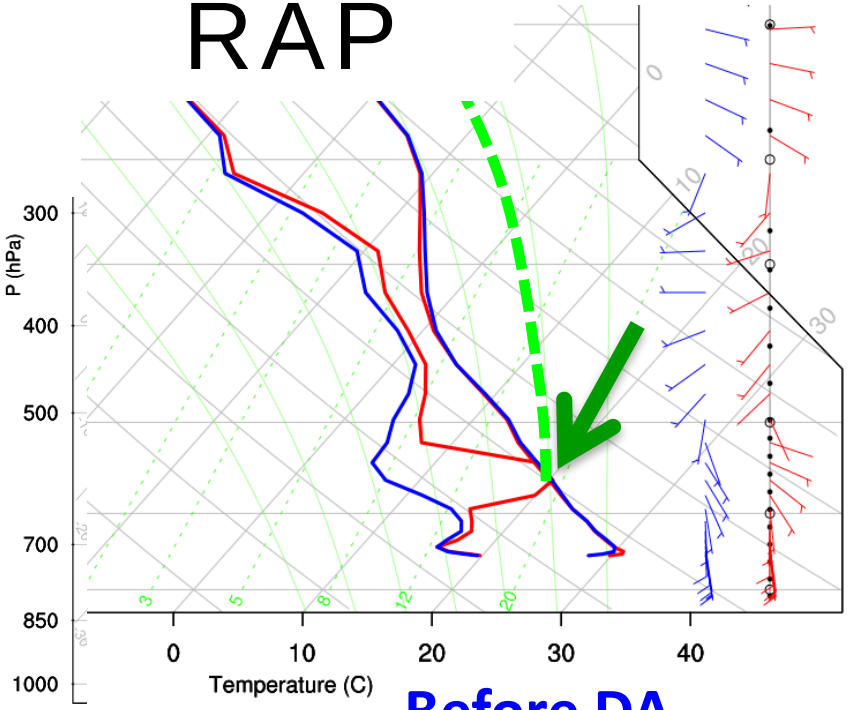




Greater retention of surface dewpoint information

Improved cloud analysis by assuming conservation of virtual potential temperature

RAP

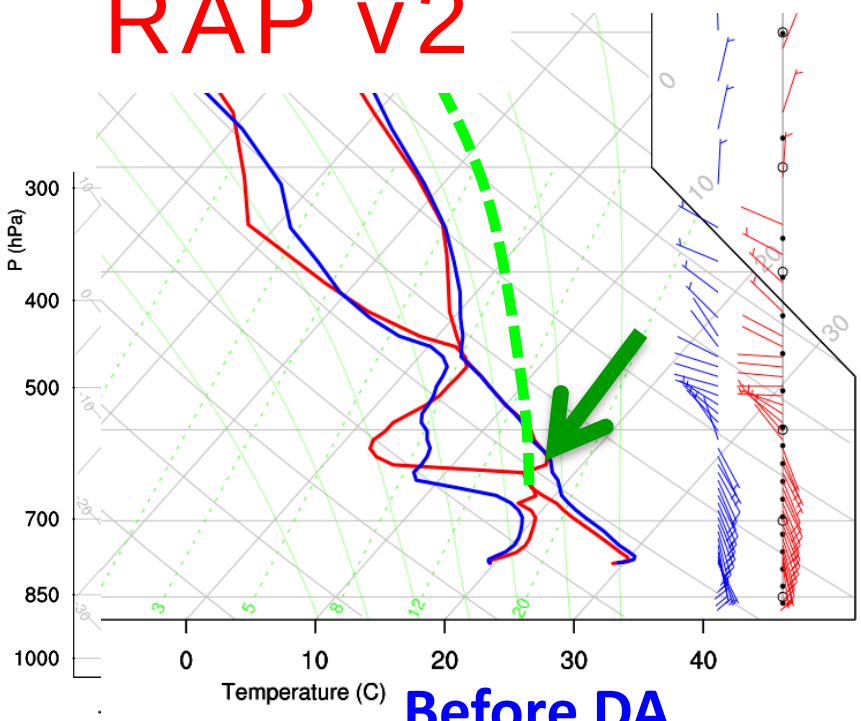


Before DA

After DA

NOT **conserving θ_v**

RAP v2



Before DA

After DA

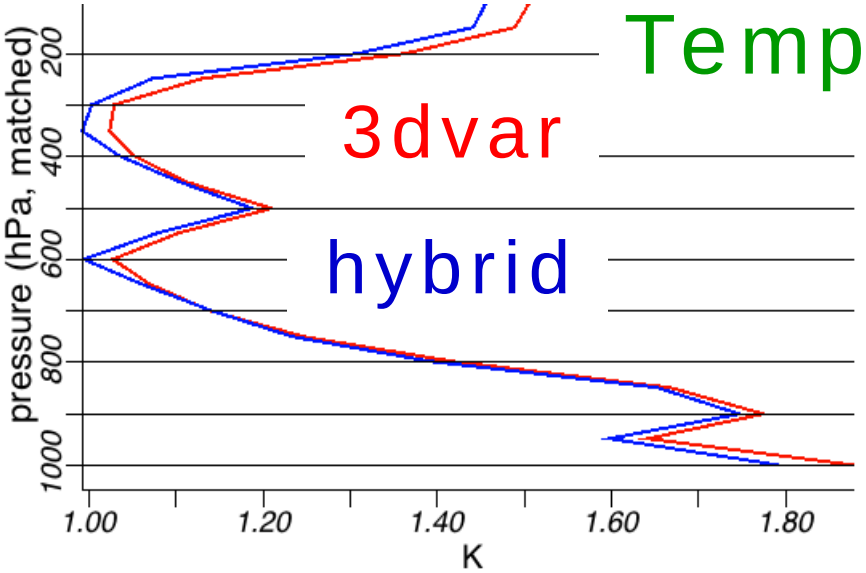
conserving θ_v

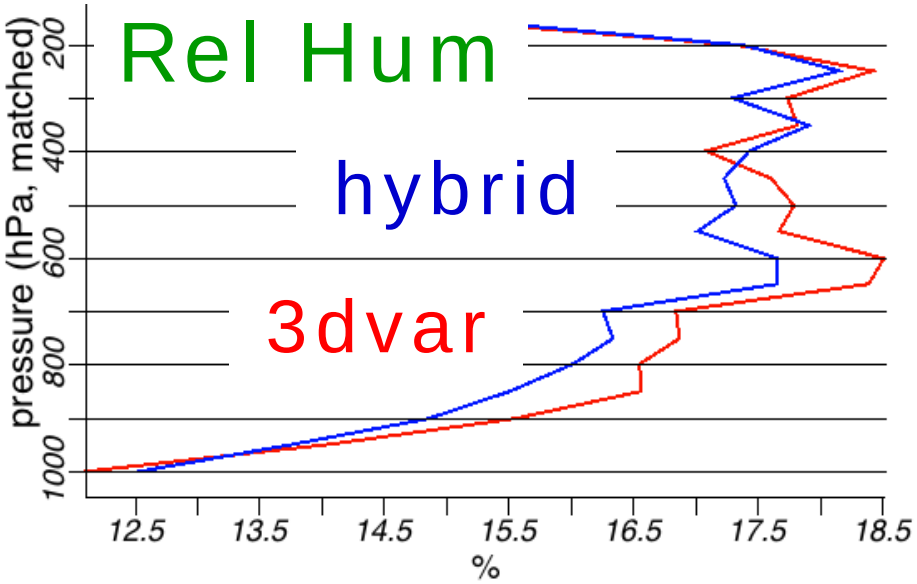
→ Reduced over-moistening, excessive CAPE

RAP version 2 Changes

	Data Assimilation	Model
RAP (13 km)	GFS ensemble background error covariance **Merge with recent GSI trunk** Sfc. moisture pseudo-obs Sfc. obs-based soil adjust Temp. dependent radar hydrometeor building Cloud assimilation mods **Conserve virtual pot. temp.** **Cloud fraction assimilation** **Full column cloud building** **Radiance bias correction** **Improved low-level thermal stability (sharper inversions via reduced obs error)** **GLD 360 lightning data**	**WRFv3.4.1+ incl. physics changes (convection, snow-radiation fix)** Numerics changes **6th-order diffusion near surface** **5th-order vertical advection** **w-damp upper bound conditions** Physics changes **MYNN PBL** **9-layer RUC LSM (from 6-layer)** **MODIS land-use (fractional)** **Modified roughness length** **Revised Thompson cloud microphysics** **RRTMG shortwave/longwave radiation** **Revised Thompson cloud microphysics**

RAP hybrid DA using global ensemble



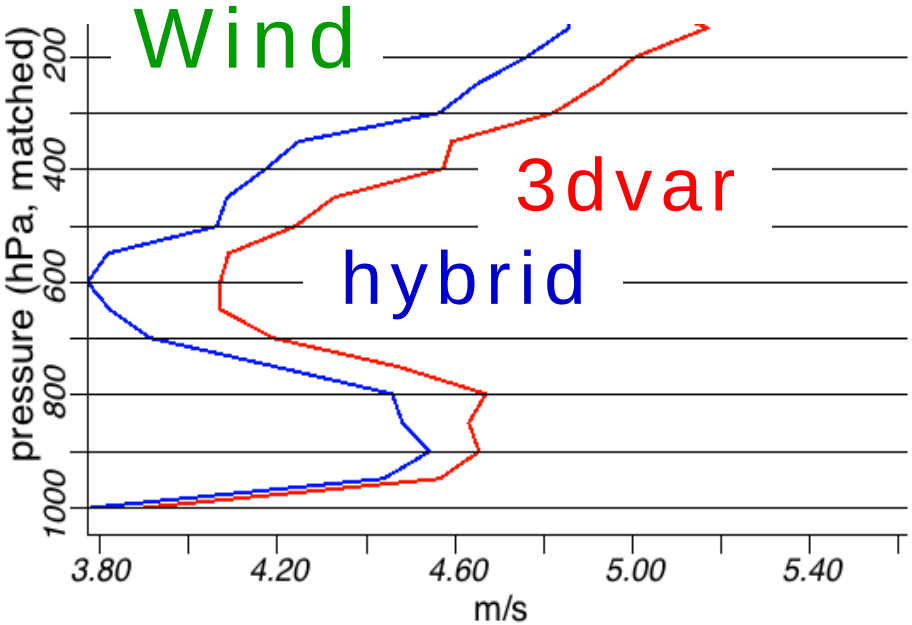


RAP GSI-hybrid vs.
RAP GSI-3dvar
upper-air verification

+ 6 h forecast

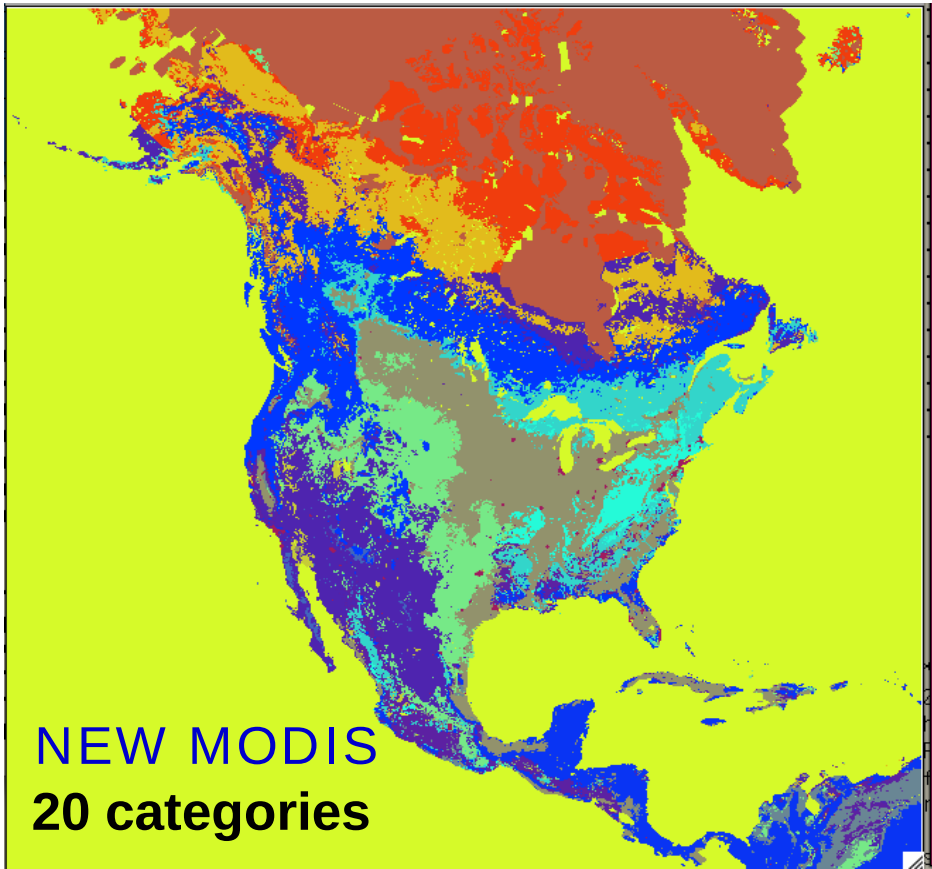
RMS Error

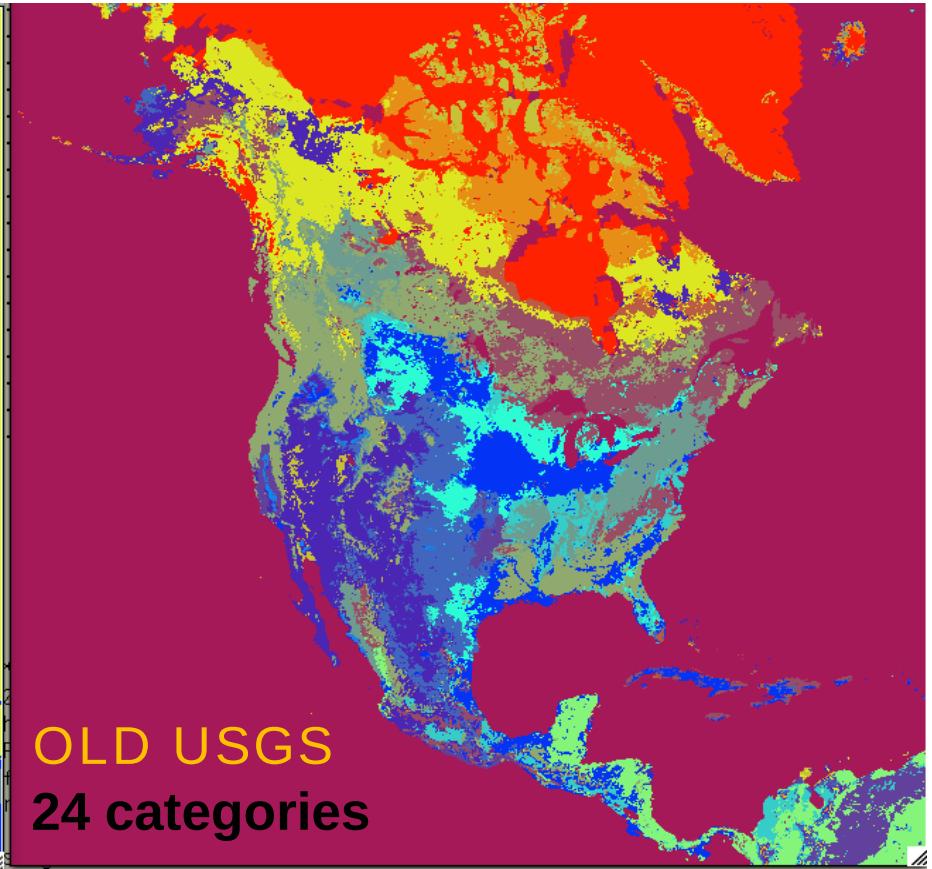
28 Nov – 3 Dec 2012



Enhancements to RUC LSM for Rapid Refrsh

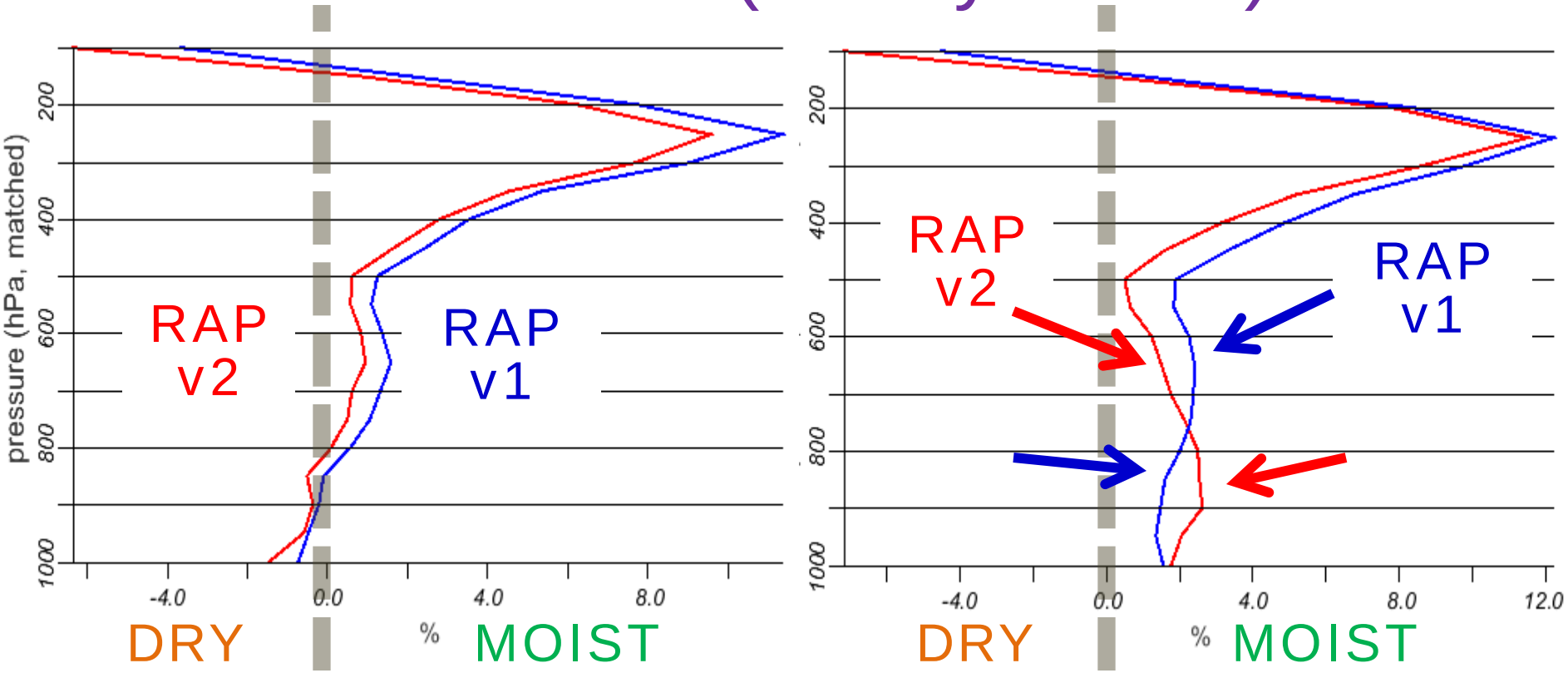
1. Seasonal variations of cropland roughness length
2. 9-layer soil model (from 6-layer)
3. New MODIS fractional land-use
4. Seasonal variations of Leaf Area Index





RAP-v2 vs. RAP-v1 relative humidity bias

+0 hr fcst (analysis fit)



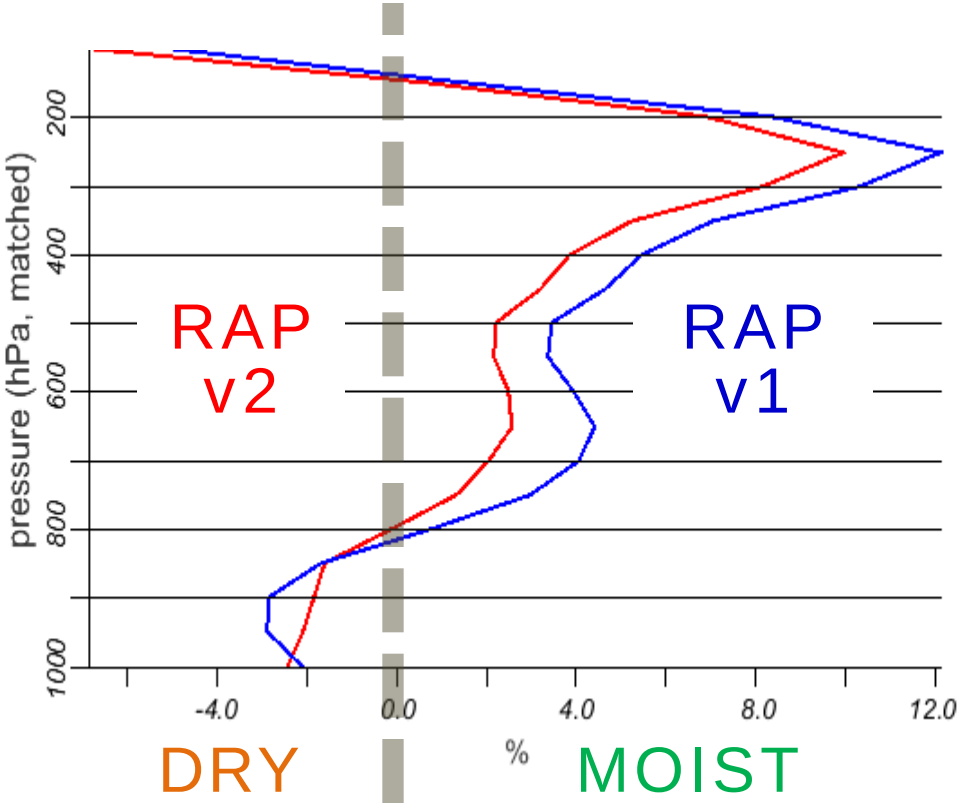
valid 12z

valid 00z

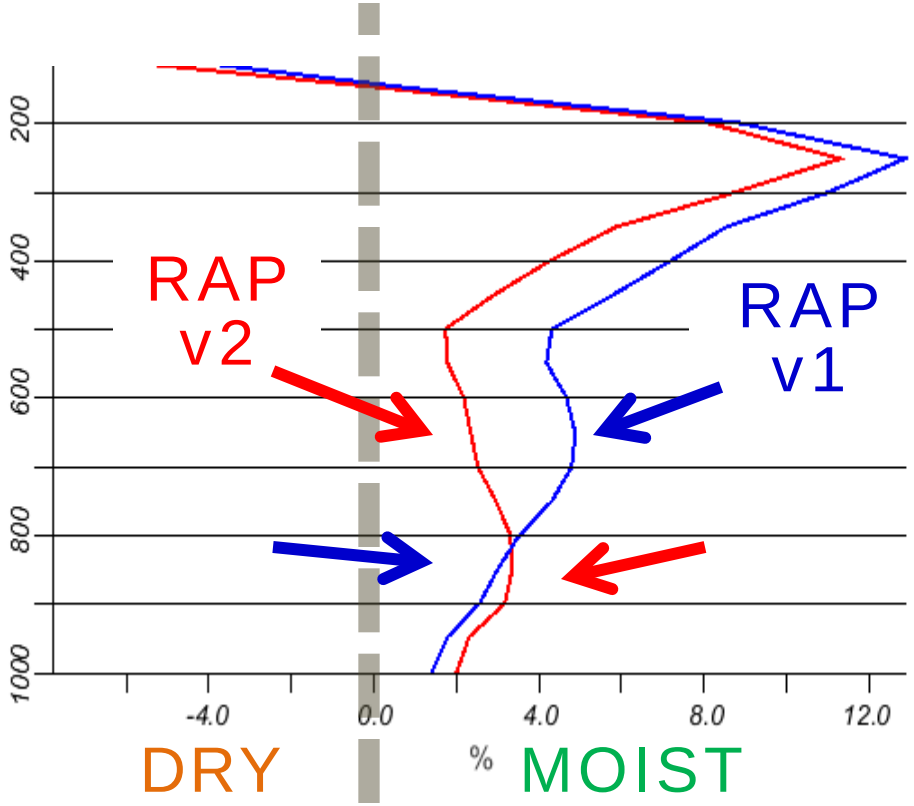
At 00z -- RAP-v2 drier at mid-levels, more moist at low-levels than RAP-v1

RAP-v2 vs. RAP-v1 relative humidity bias

+1 hr forecast



valid 12z



valid 00z

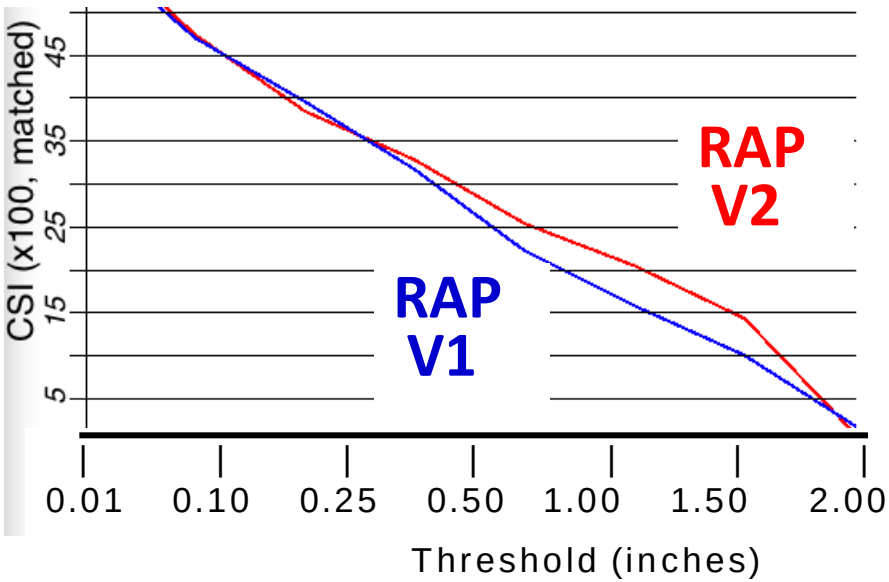
At 00z -- RAP-v2 drier at mid-levels, more moist at low-levels than RAP-v1

RAP Precipitation Verification

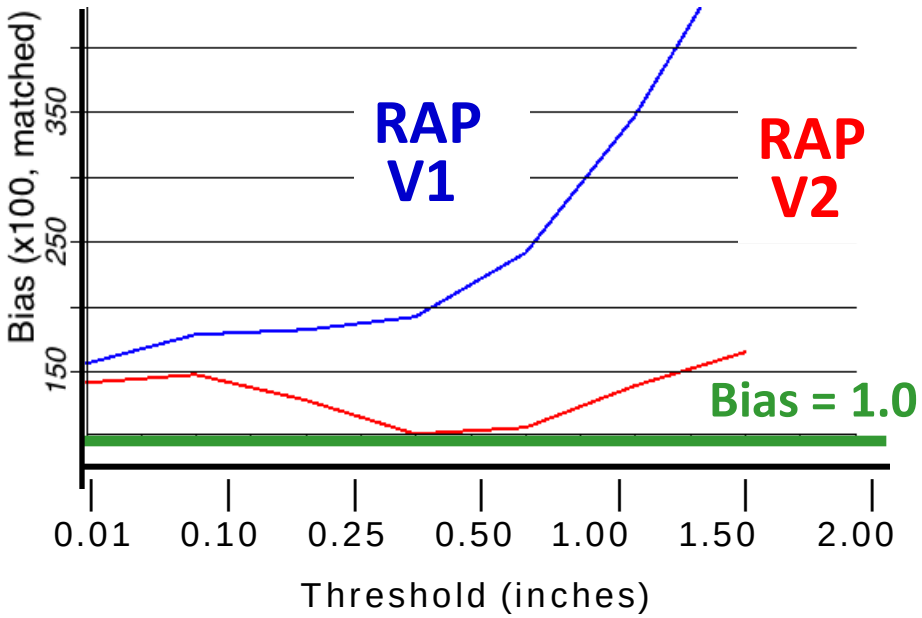
Eastern US, 8x3hr Forecasts vs. 24h CPC

11-21 August 2011

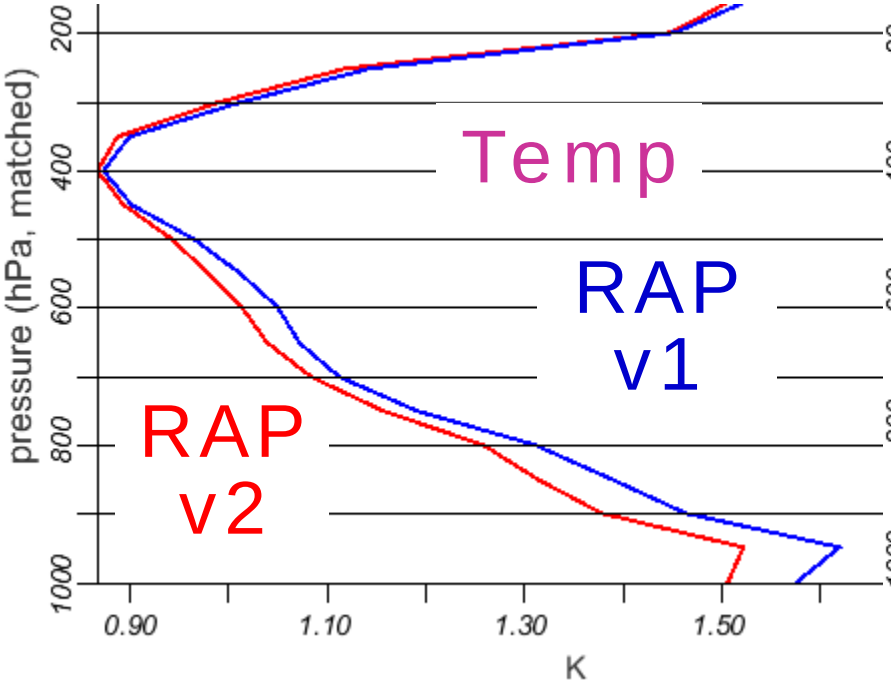
CSI 13 km

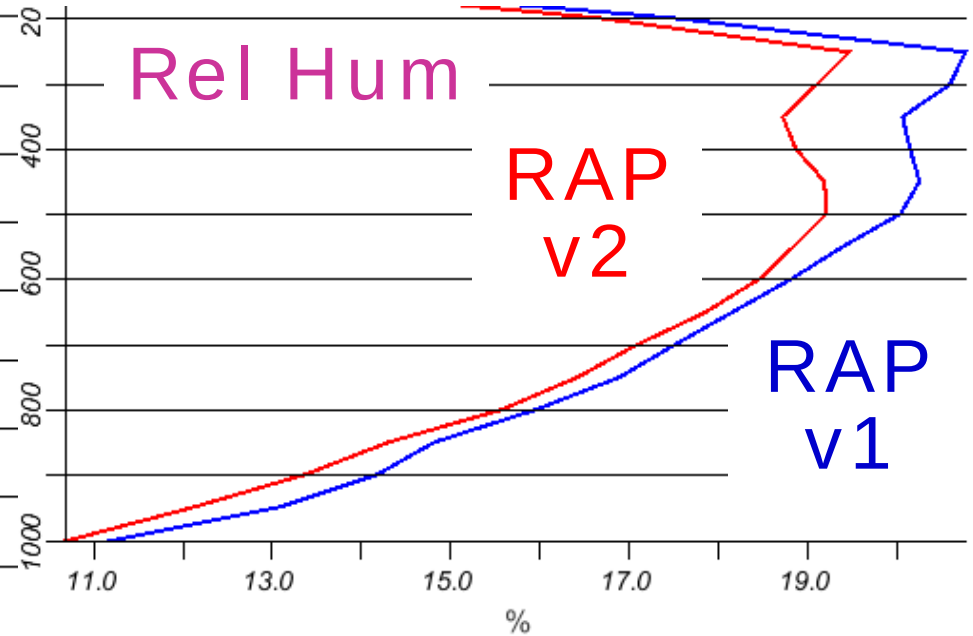


Bias 13km



RAP version 2 has similar CSI, much improved bias





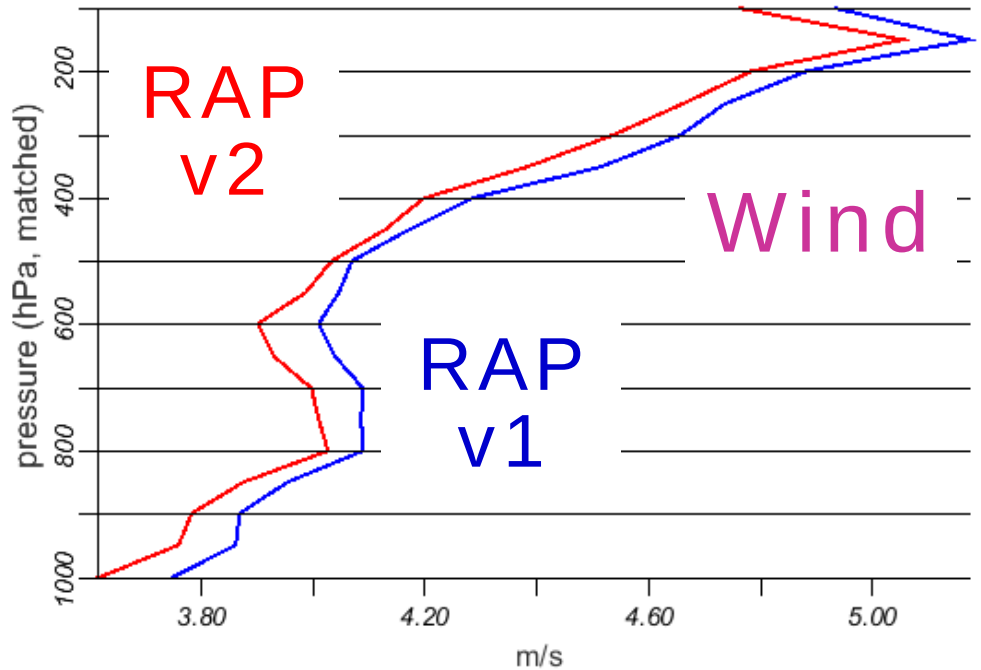
RAP-v2 vs. RAP-v1

upper-air verification

+ 3h forecast

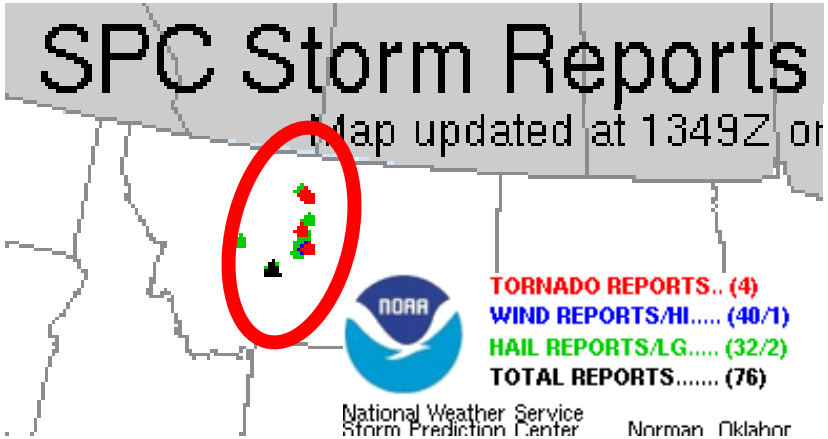
RMS Error

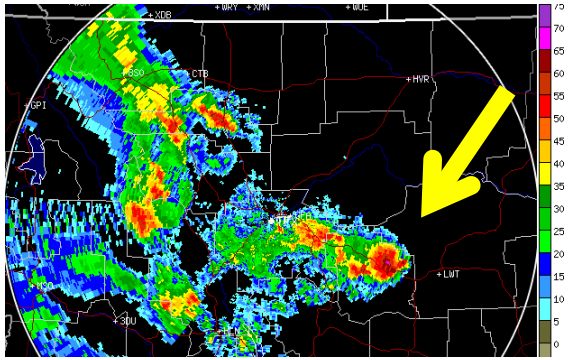
1 May 2012 – 31 Aug 2012



June 5, 2012: Montana Supercells
(courtesy Israel Jirak, Steve Weiss, SPC)

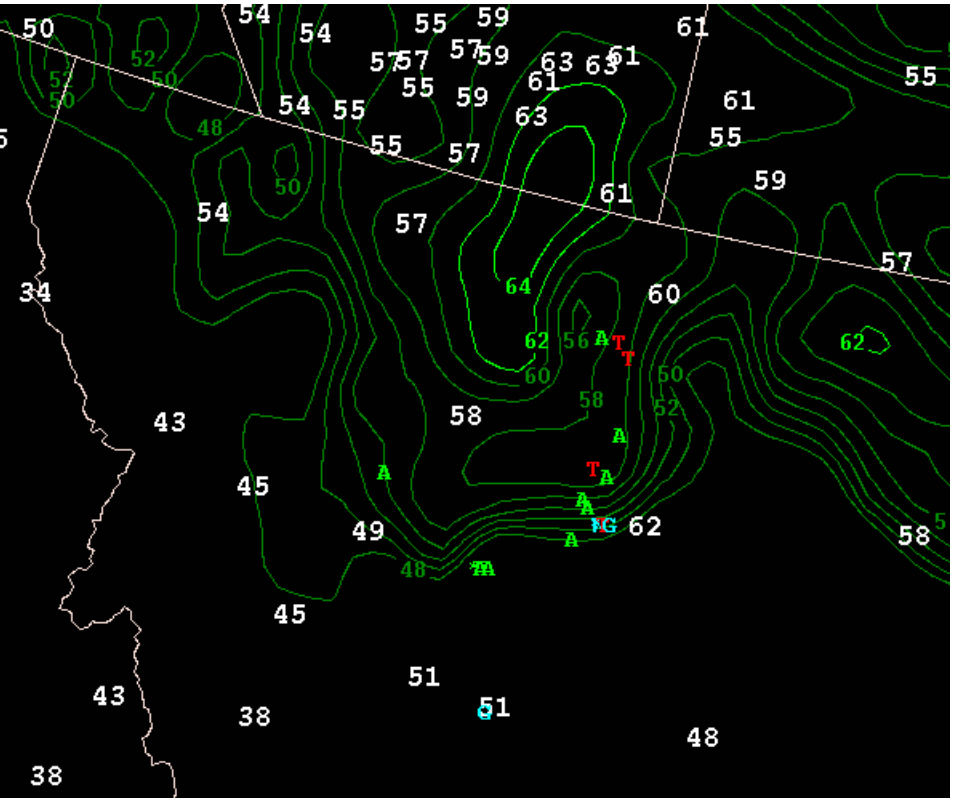
- Severe storms including a long-lived supercell moving northward across central Montana
  - 4 tornado reports, hail up to 2” diameter, and wind gusts to 90 mph



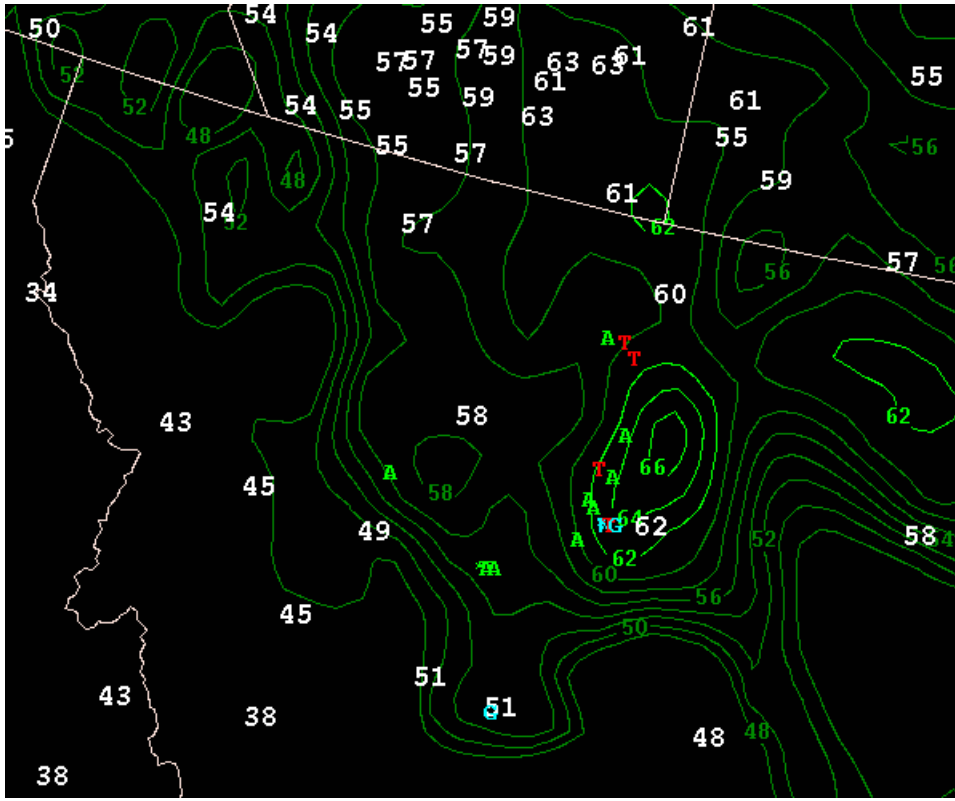


Choteau County MT ***(from KRTV, Great Falls)***

June 5, 2012: MT Supercell
sfcOA 2-m Dewpoint Valid 21Z
(courtesy Israel Jirak, Steve Weiss, SPC)

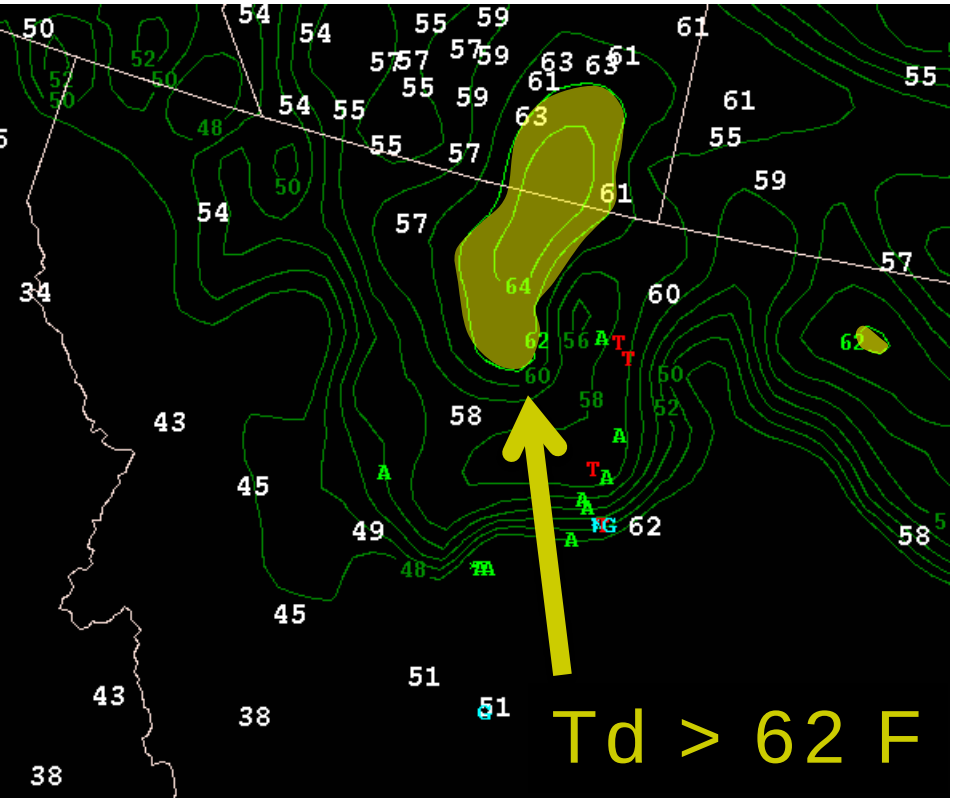


RAP

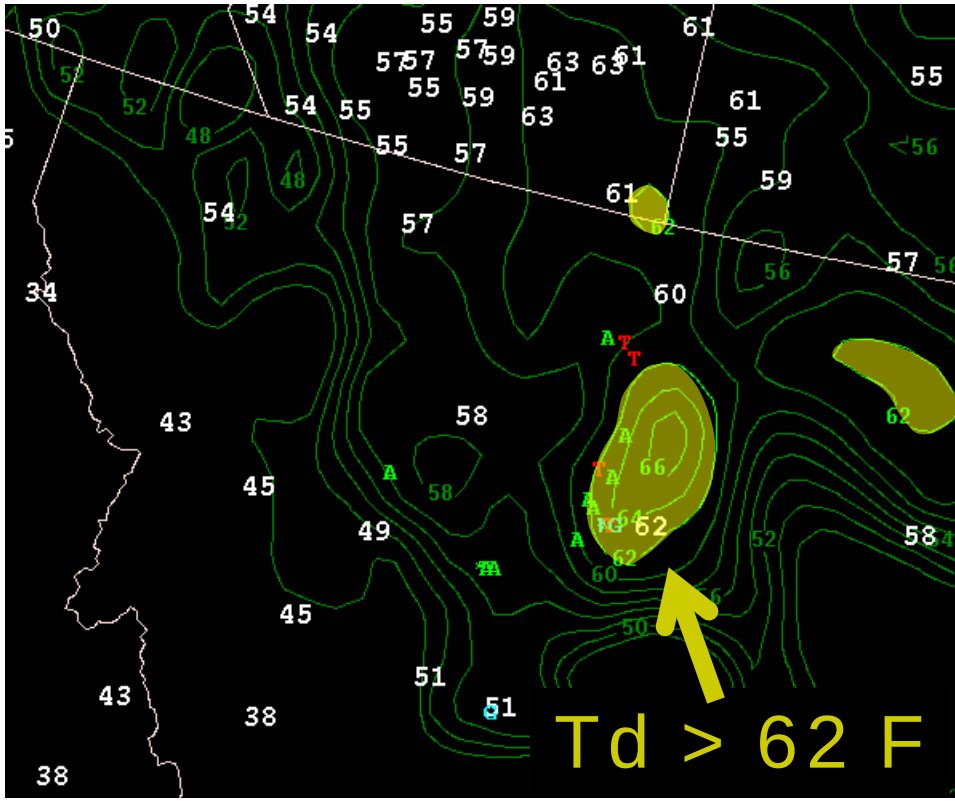


RAPv2

June 5, 2012: MT Supercell
sfcOA 2-m Dewpoint Valid 21Z
(courtesy Israel Jirak, Steve Weiss, SPC)

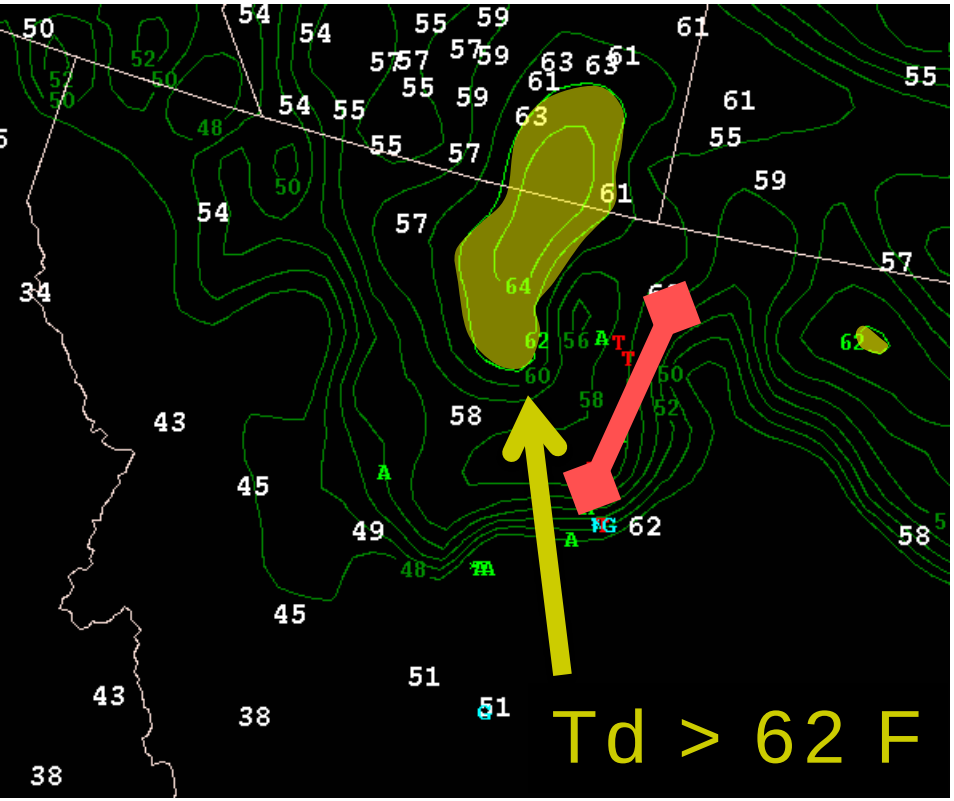


RAP

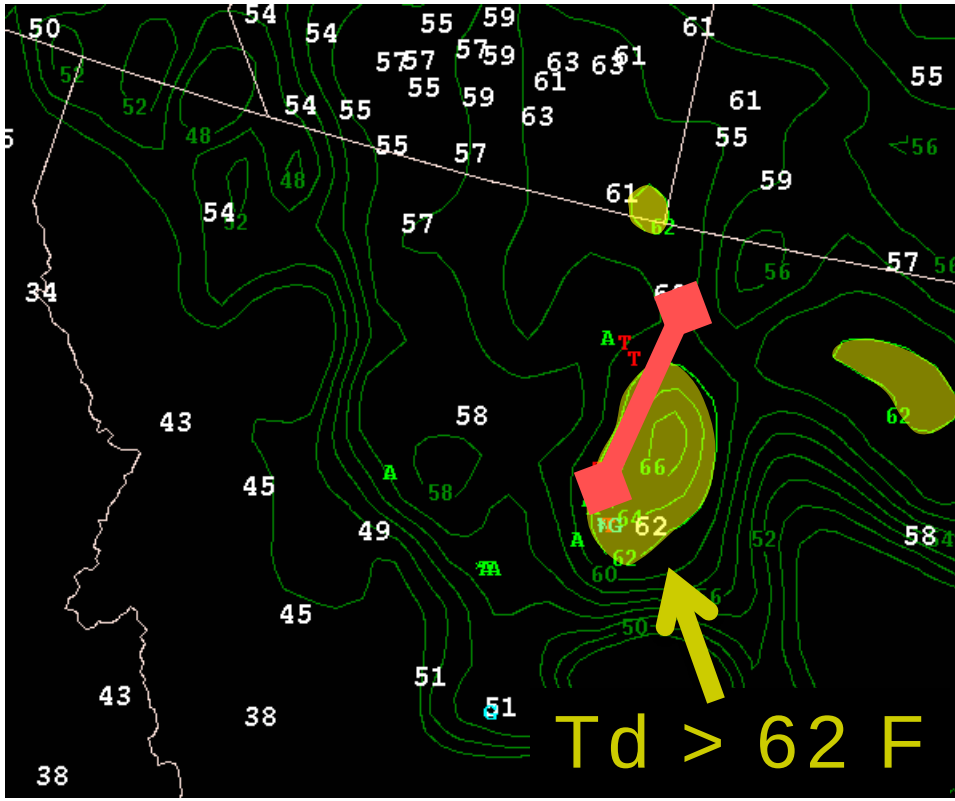


RAPv2

June 5, 2012: MT Supercell
sfcOA 2-m Dewpoint Valid 21Z
(courtesy Israel Jirak, Steve Weiss, SPC)

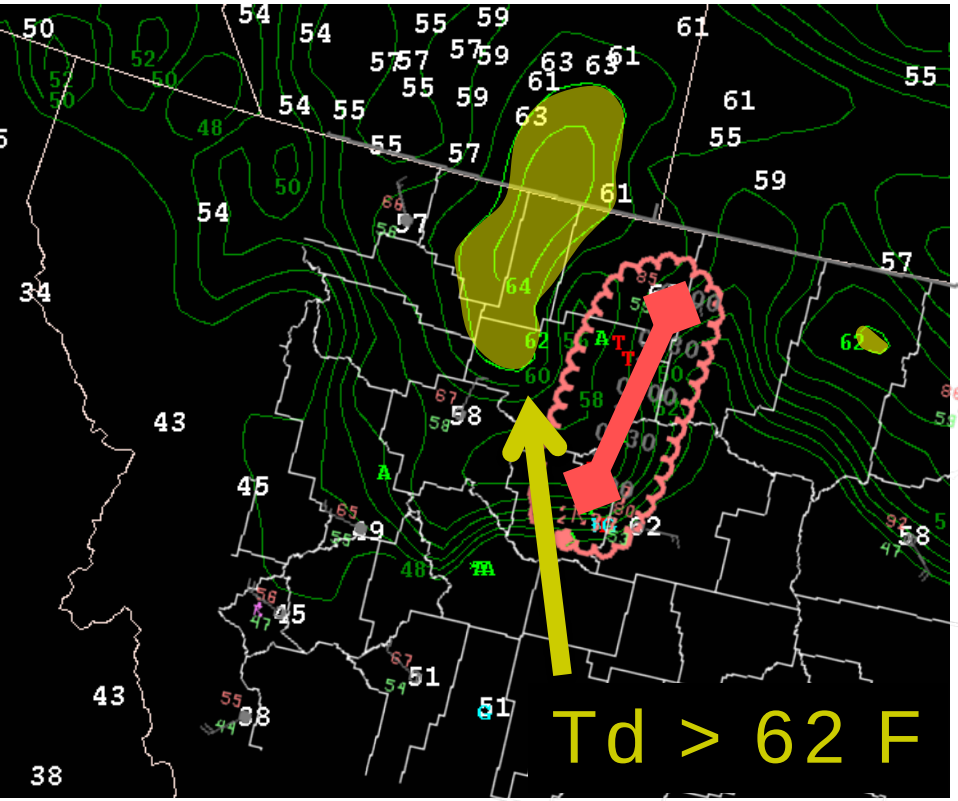


RAP

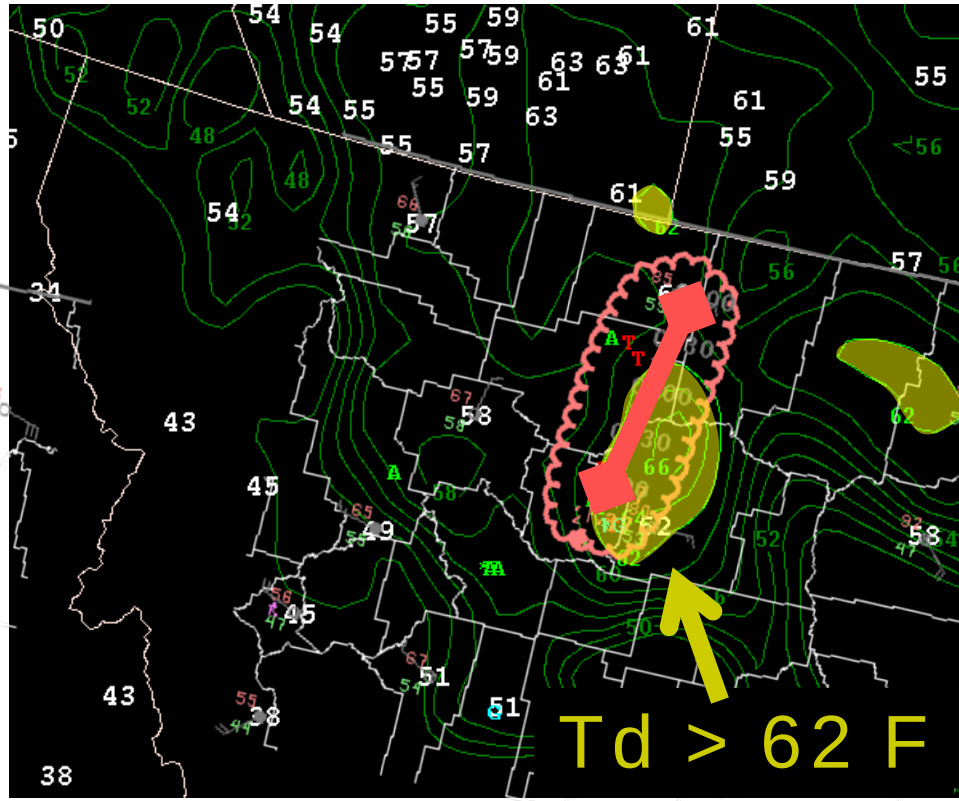


RAPv2

June 5, 2012: MT Supercell
sfcOA 2-m Dewpoint Valid 21Z
(courtesy Israel Jirak, Steve Weiss, SPC)



RAP

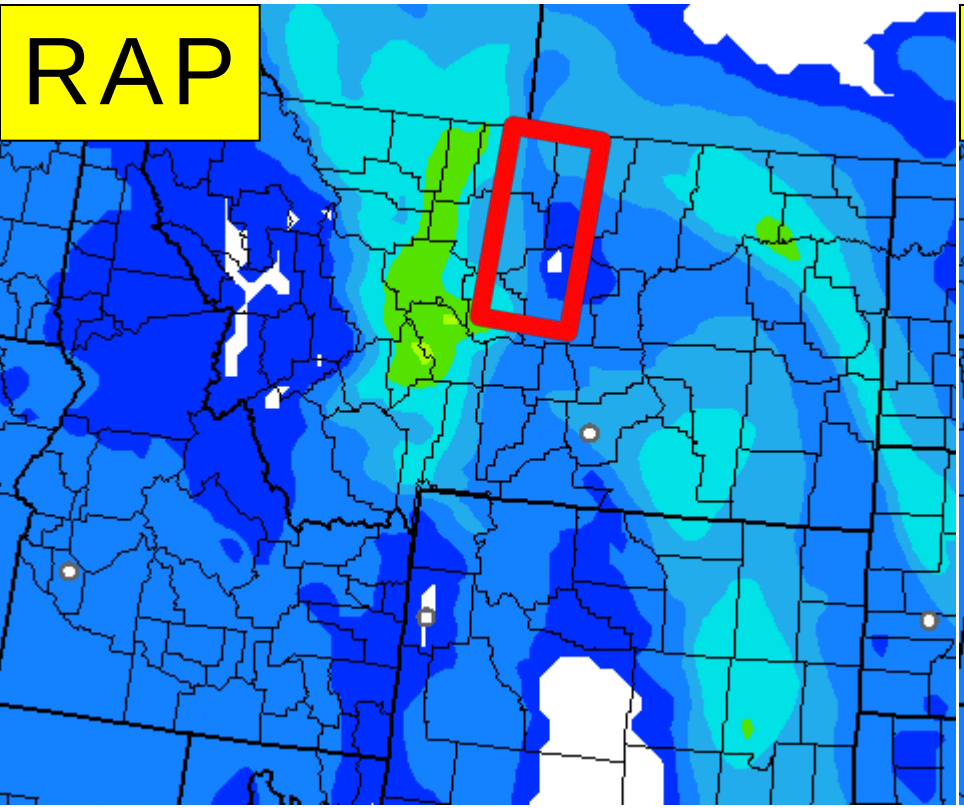


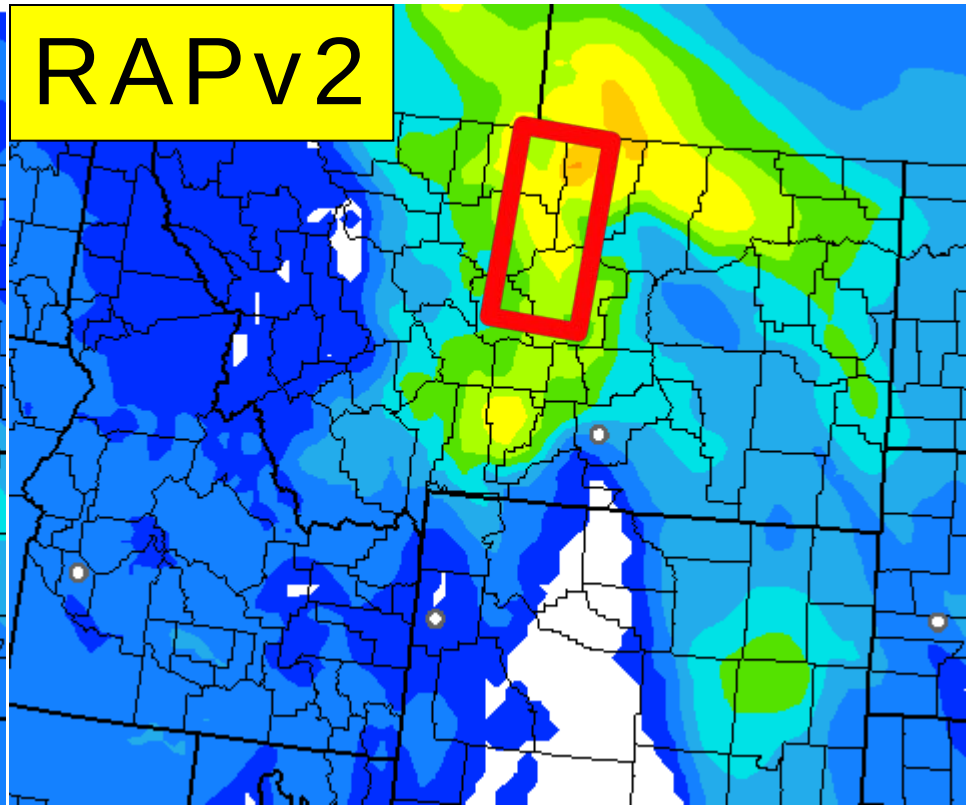
RAPv2

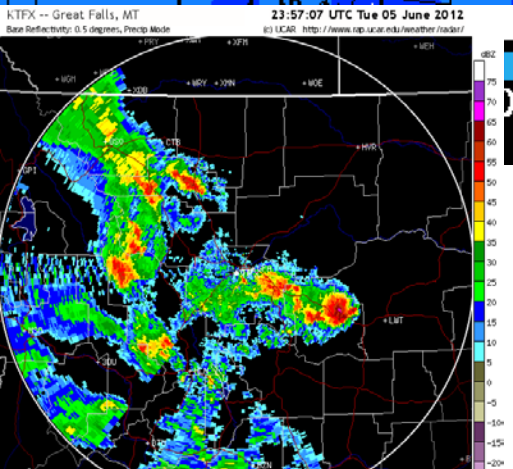
SPC MCD #1079

SPC MCD #1079

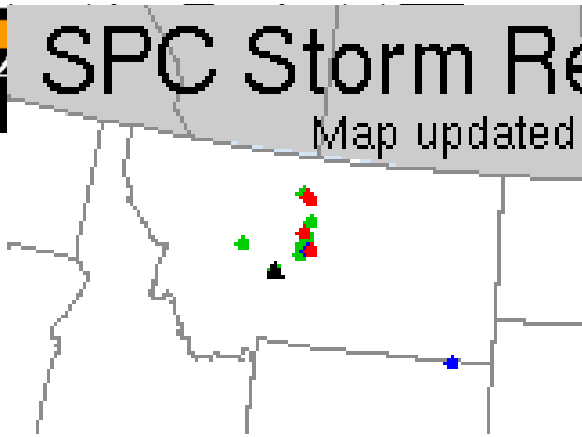
June 5, 2012: MT upercell
1-hr forecast SBCAPE Valid 00Z 6 June





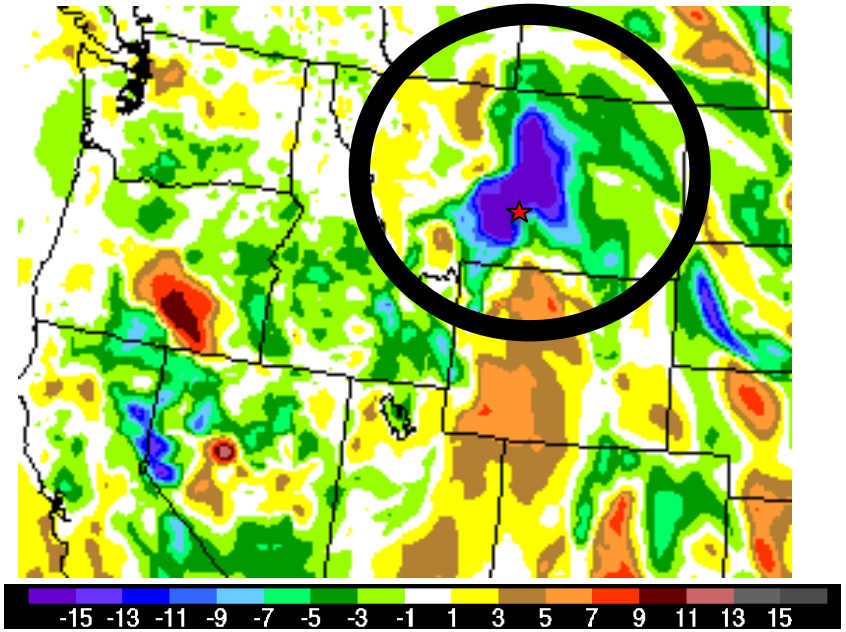


RAP-v2 instability forecasts better than RAP

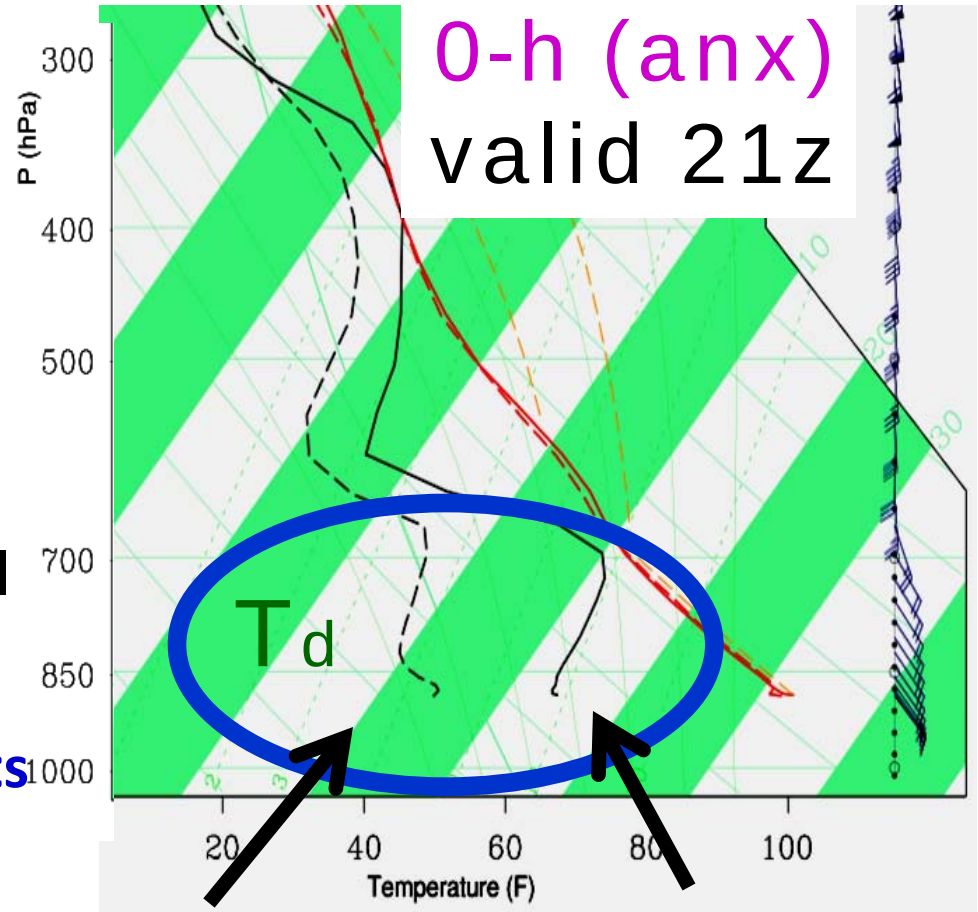


June 5, 2012: MT Supercell

0-hr fcst sfc. Dewpoint & Soundings Valid 21Z



RAPv1 - RAPv2 dewpoint (deg F)



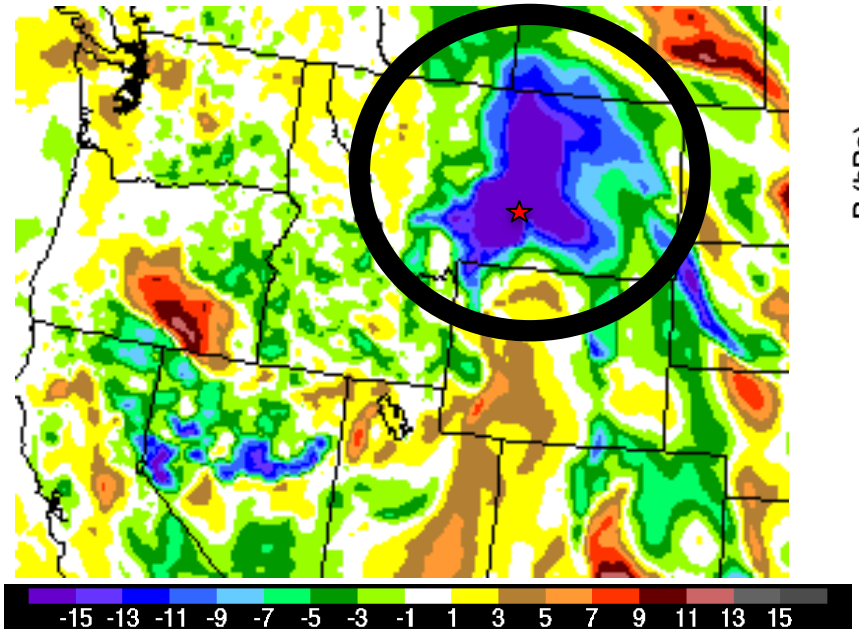
RAP-v1 RAP-v2

- **RAP "v1" Central MT dewpoints >15 F drier than RAP "v2"**
- **RAP "v1" drier than RAP "v2" from surface up to ~300 mb, much drier boundary layer near LWT**

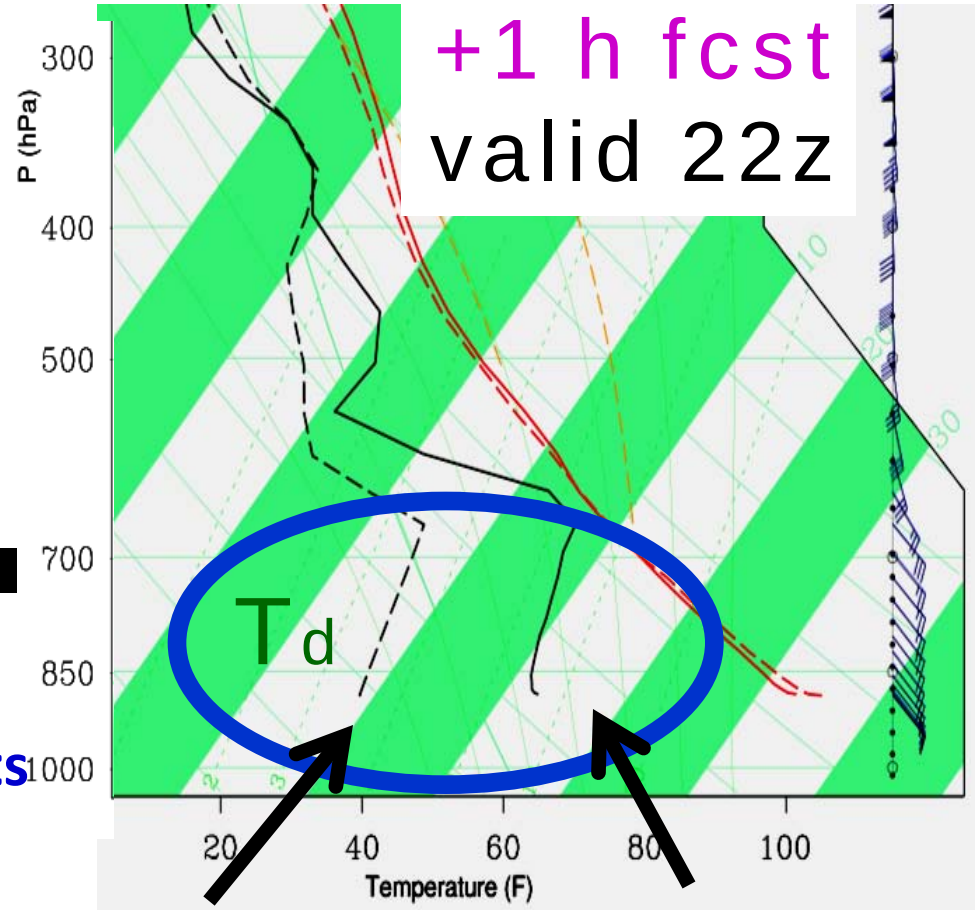
Skew-t near 47.2N, 108.7W (ene LWT)
Solid lines: RAPv2 Dashed lines: RAP

June 5, 2012: MT Supercell

1-hr fcst sfc. Dewpoint & Soundings Valid 22Z



RAPv1 - RAPv2 dewpoint (deg F)



RAP-v1 RAP-v2

- **RAP "v1" Central MT dewpoints >15 F drier than RAP "v2"**
- **RAP "v1" drier than RAP "v2" from surface up to ~300 mb, much drier boundary layer near LWT**

Skew-t near 47.2N, 108.7W (ene LWT)
Solid lines: RAPv2 Dashed lines: RAP

RAP Summary and Plans

- **RAP "v1" implemented at NCEP 1 May 2012**
- **Improved RAP "v2" – real-time runs Jet/Zeus**
  - **Updated trunk versions of WRF-ARW and GSI**
  - **ARW model enhancements (LSM, PBL, microphys, radiation)**
  - **Improved assimilation for moisture (PBL / soil / radar)**
  - Use of GFS ensemble background error covariance
- **Continued work / inclusion in next implement**
  - **Refinements to use of GFS ensemble information**
  - **Refinements to satellite radiance assimilation**

Hourly Updated NWP Models

13km Rapid Refresh (RAP) (mesoscale)

Replaced RUC at NCEP 05/01/12

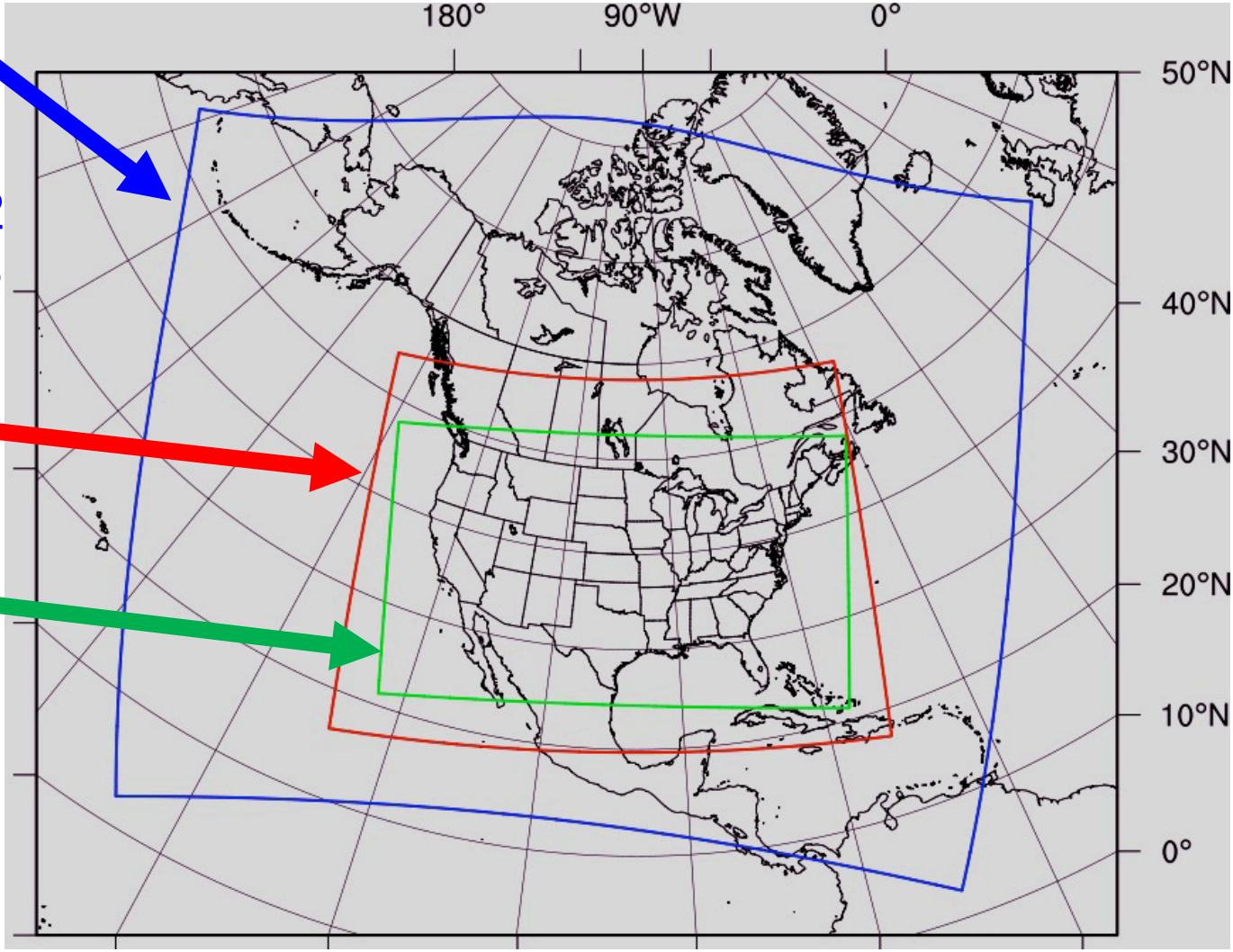
WRF, GSI, RUC features

13km RUC (mesoscale)

3km HRRR (storm-scale)

High-Resolution Rapid Refresh

Experimental 3km nest inside RAP, hourly 15-h fcst



HRRR Forecast Behavior

2011

(1) **High bias** in convection over **eastern US**

(2) **False alarms**

(3) **Lead** in convective initiation (early AM runs)

(4) **Difficulty** maintaining **mesoscale convective systems**

(5) **Reflectivity biases** in snow and convective storms

RAP / HRRR Model Development and Evaluation

2012 Targets

(1) **Lower peak bias** in convection over **eastern US**

(2) **Fewer false alarms**

(3) **Improved timing** of convective initiation

(4) **More success** maintaining **mesoscale convective systems**

(5) **More realistic reflectivity**

RAP and HRRR Changes 2011-2012

Red = Changes in current RAP/HRRR effective before 09 March 2012

	Model	Data Assimilation
RAP-ESRL (13 km)	**WRFv3.3.1+** **Numerics changes:** **(w-damp upper bound conditions, 5th-order vertical advection)** **Physics changes:** **(microphysics, land-surface, PBL)** **MODIS land use, fractional** **30→05 min shortwave radiation** **New reflectivity diagnostic**	**GSI merge with trunk** **Soil adjustment** **Temp-dep radar-hydrometeor building** **PW assim mods** **Cloud assim mods** **Tower/nacelle/sodar observations** **GLD360 lightning**
HRRR (3 km)	**WRFv3.3.1+** **Numerics changes:** **(w-damp upper bound conditions, 5th-order vertical advection)** **Physics changes:** **(microphysics, land-surface, PBL)** **MODIS land use, fractional** **30→05 min shortwave radiation** **New reflectivity diagnostic**	

RAP and HRRR Config 2011

Model	Run at:	Domain	Grid Points	Grid Spacing	Vertical Levels	Pressure Top	Boundary Conditions	Initialized
RAP	GSD, NCO	North America	758 x 567	13 km	50	10 mb	GFS	Hourly (cycled)
HRRR	GSD	CONUS	1799 x 1059	3 km	50	20 mb	RAP	Hourly - RAP (no-cycle)

Model	Version	Assimilation	Radar DFI	Radiation	Microphysics	Cum Param	PBL	LSM
RAP	WRF-ARW v3.2.1+	GSI-3DVAR	Yes	RRTM/Goddard	Thompson	G3 + Shallow	MYJ	RUC
HRRR	WRF-ARW V3.2.1+	None: RAP I.C.	No	RRTM/ Dudhia	Thompson	None	MYJ	RUC

Model	Horiz/Vert Advection	Scalar Advection	Upper-Level Damping	SW Radiation Update	Land Use	MP Tend Limit	Time-Step
RAP	$5^{th}/3^{rd}$	Monotonic	Diffusive 0.02	30 min	USGS	0.01 K/s	60 s
HRRR	$5^{th}/3^{rd}$	Monotonic	Diffusive 0.02	30 min	USGS	0.10 K/s	18-23 s

RAP and HRRR Config 2012

Model	Run at:	Domain	Grid Points	Grid Spacing	Vertical Levels	Pressure Top	Boundary Conditions	Initialized
RAP	GSD, NCO	North America	758 x 567	13 km	50	10 mb	GFS	Hourly (cycled)
HRRR	GSD	CONUS	1799 x 1059	3 km	50	20 mb	RAP	Hourly - RAP (no-cycle)

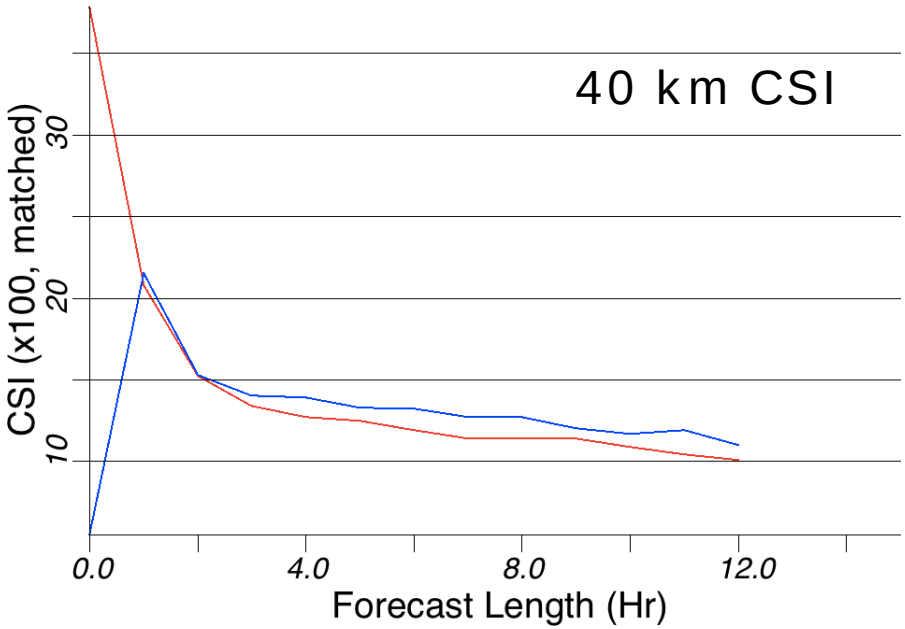
Model	Version	Assimilation	Radar DFI	Radiation	Microphysics	Cum Param	PBL	LSM
RAP	WRF-ARW v3.3.1+	GSI-3DVAR	Yes	RRTM/Goddard	Thompson	G3 + Shallow	MYJ	RUC
HRRR	WRF-ARW v3.3.1+	None: RAP I.C.	No	RRTM/Dudhia	Thompson	None	MYJ	RUC

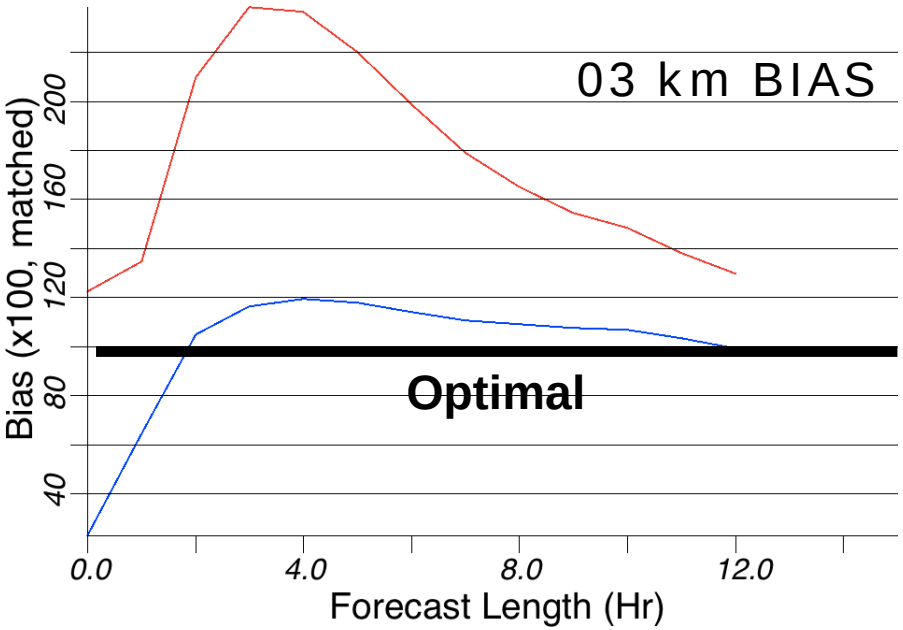
Model	Horiz/Vert Advection	Scalar Advection	Upper-Level Damping	SW Radiation Update	Land Use	MP Tend Limit	Time-Step
RAP	$5^{th}/5^{th}$	Positive-Definite	w-Rayleigh 0.2	10 min	MODIS Fractional	0.01 K/s	60 s
HRRR	$5^{th}/5^{th}$	Positive-Definite	w-Rayleigh 0.2	5 min	MODIS Fractional	0.07 K/s	20-23 s

HRRR June Retro Verification

HRRR 2011
HRRR 2012

Reflectivity Eastern US
160 Runs 29 May – 12 June 2011
Reflectivity ≥ 30 dBZ





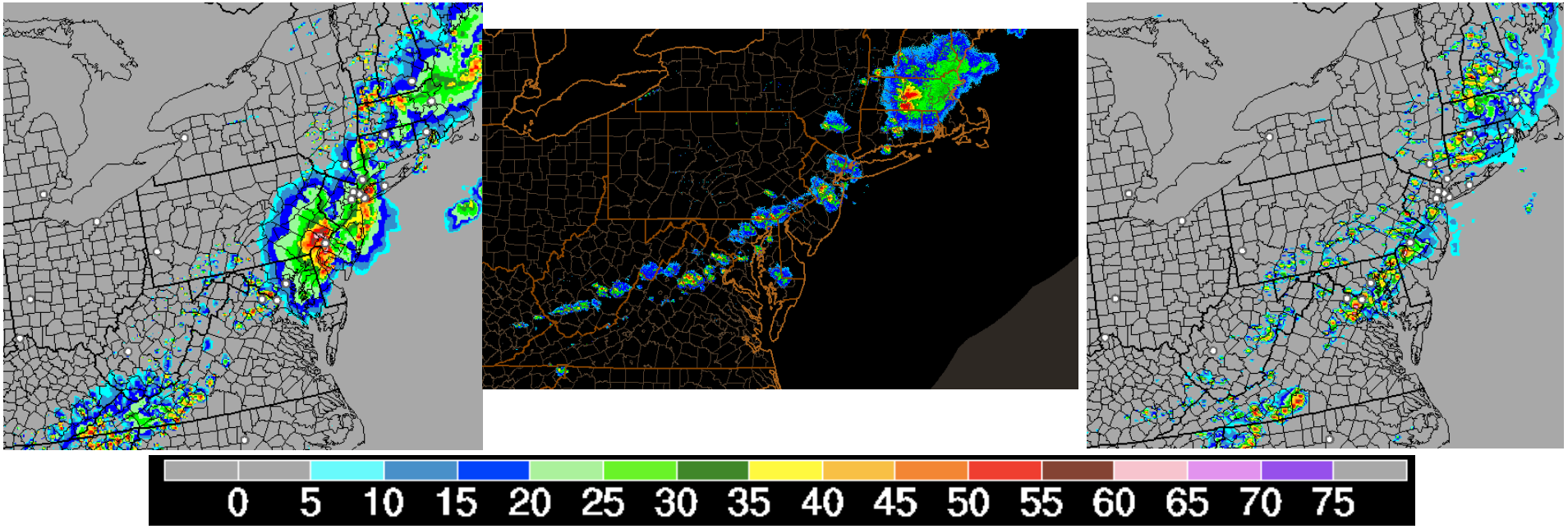
Reduced high bias in first 6 hrs and improved CSI

HRRR Retro Case Studies

HRRR 5hr fcst
2011 Real-Time

21z 01 June 2011
Observations

HRRR 5hr fcst
2012 Version



Composite Reflectivity (dBZ)

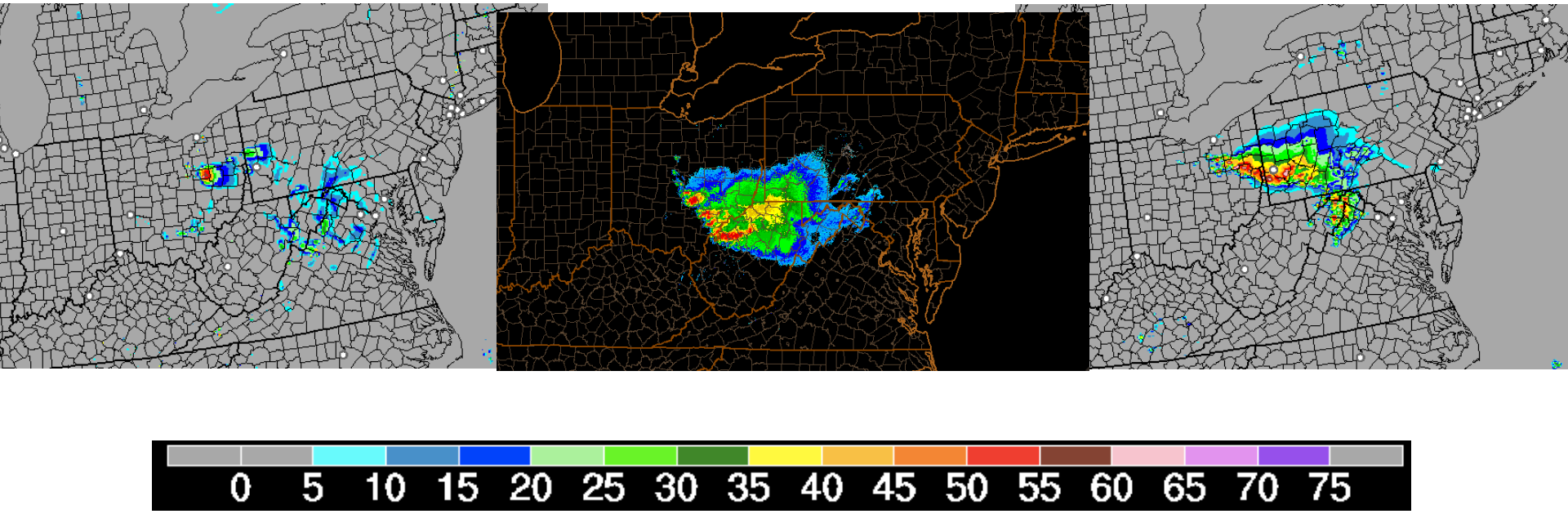
Large reduction in false alarm (excessive) convection
Improved structure to broken convective line

HRRR Retro Case Studies

HRRR 10hr fcst
2011 Real-Time

18z 07 June 2011
Observations

HRRR 10hr fcst
2012 Version



Composite Reflectivity (dBZ)

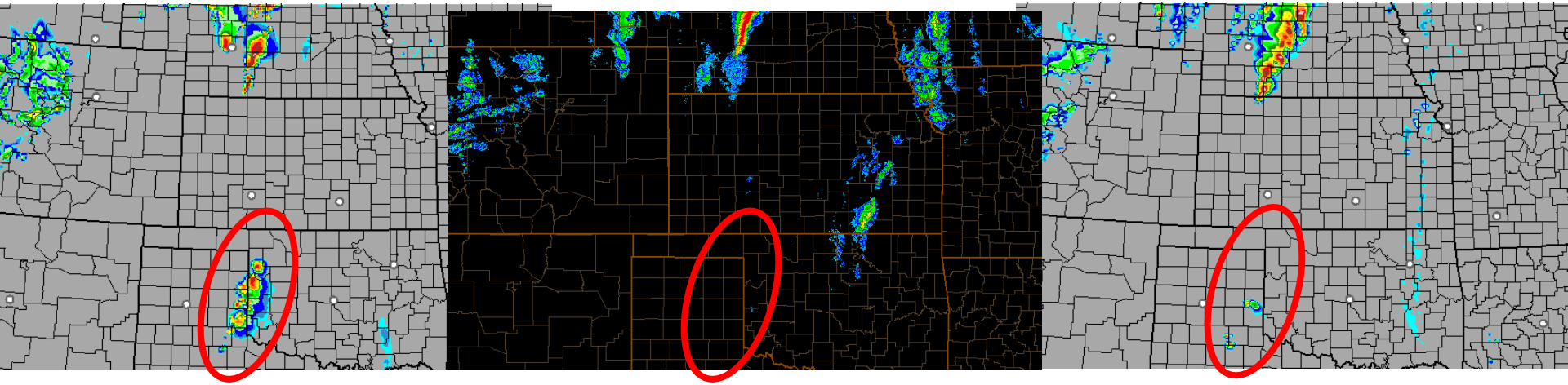
Improved mesoscale convective system (MCS) maintenance

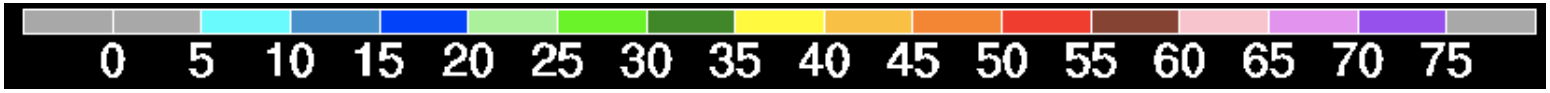
HRRR Retro Case Studies

HRRR 8hr fcst
2011 Real-Time

00z 31 May 2011
Observations

HRRR 8hr fcst
2012 Version



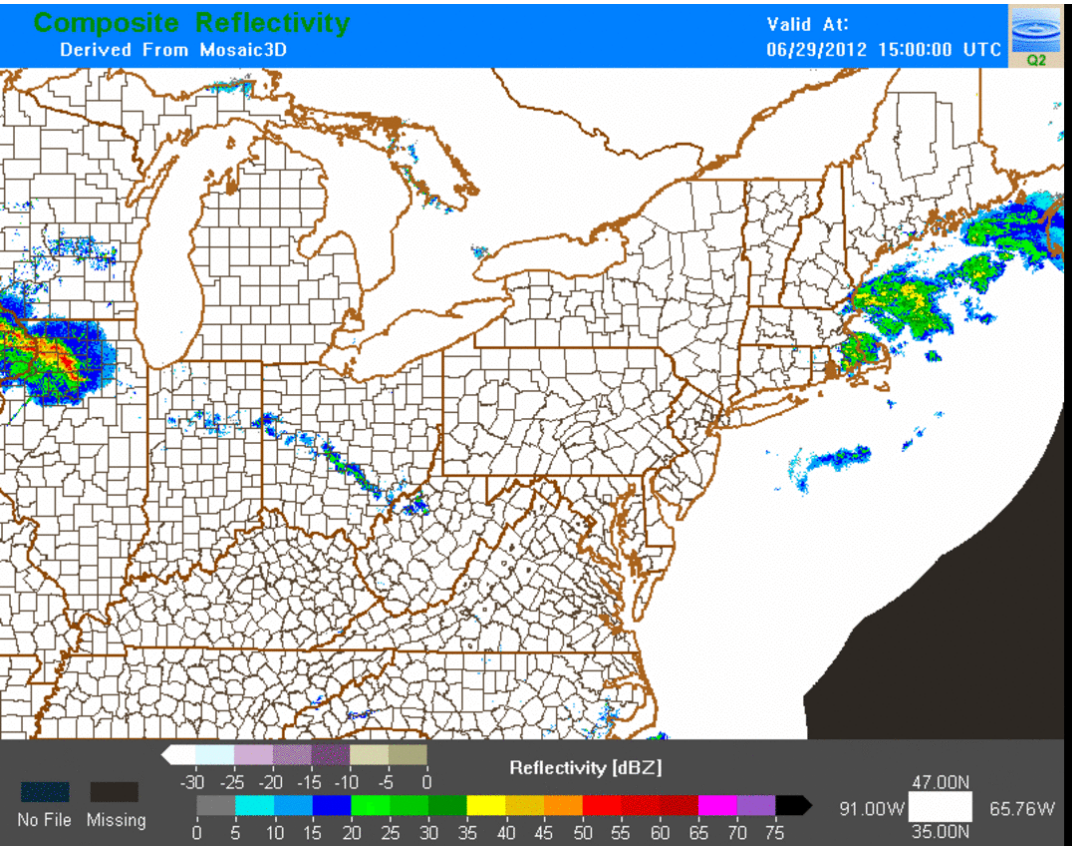


Composite Reflectivity (dBZ)

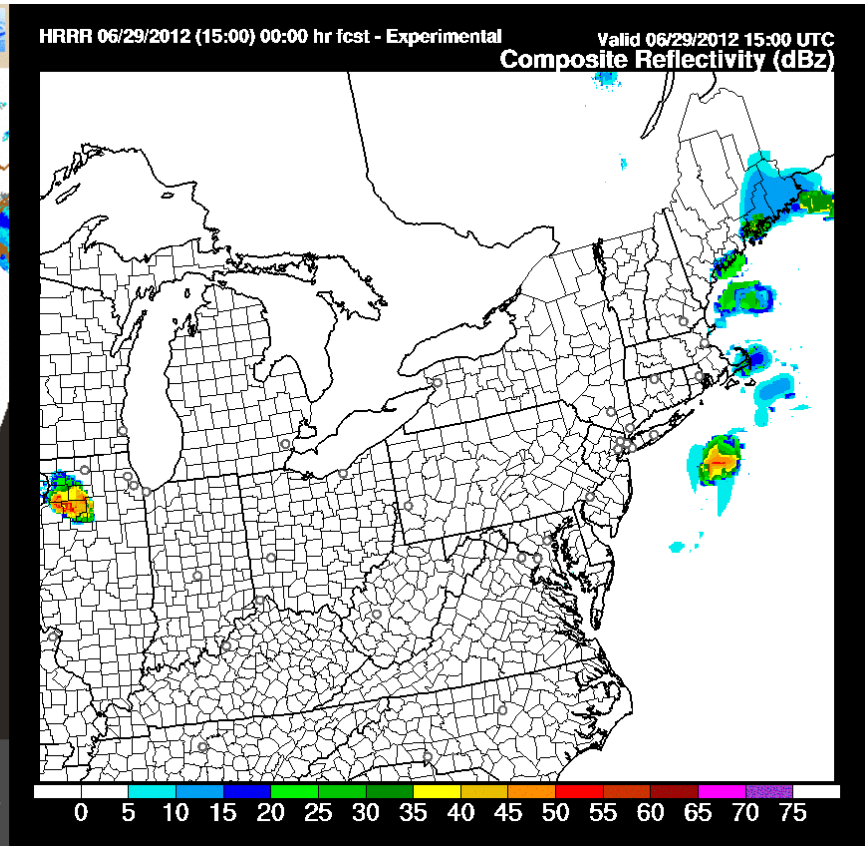
Reduction in false alarm convective initiation

HRRR Derecho Forecast

Reflectivity Observations

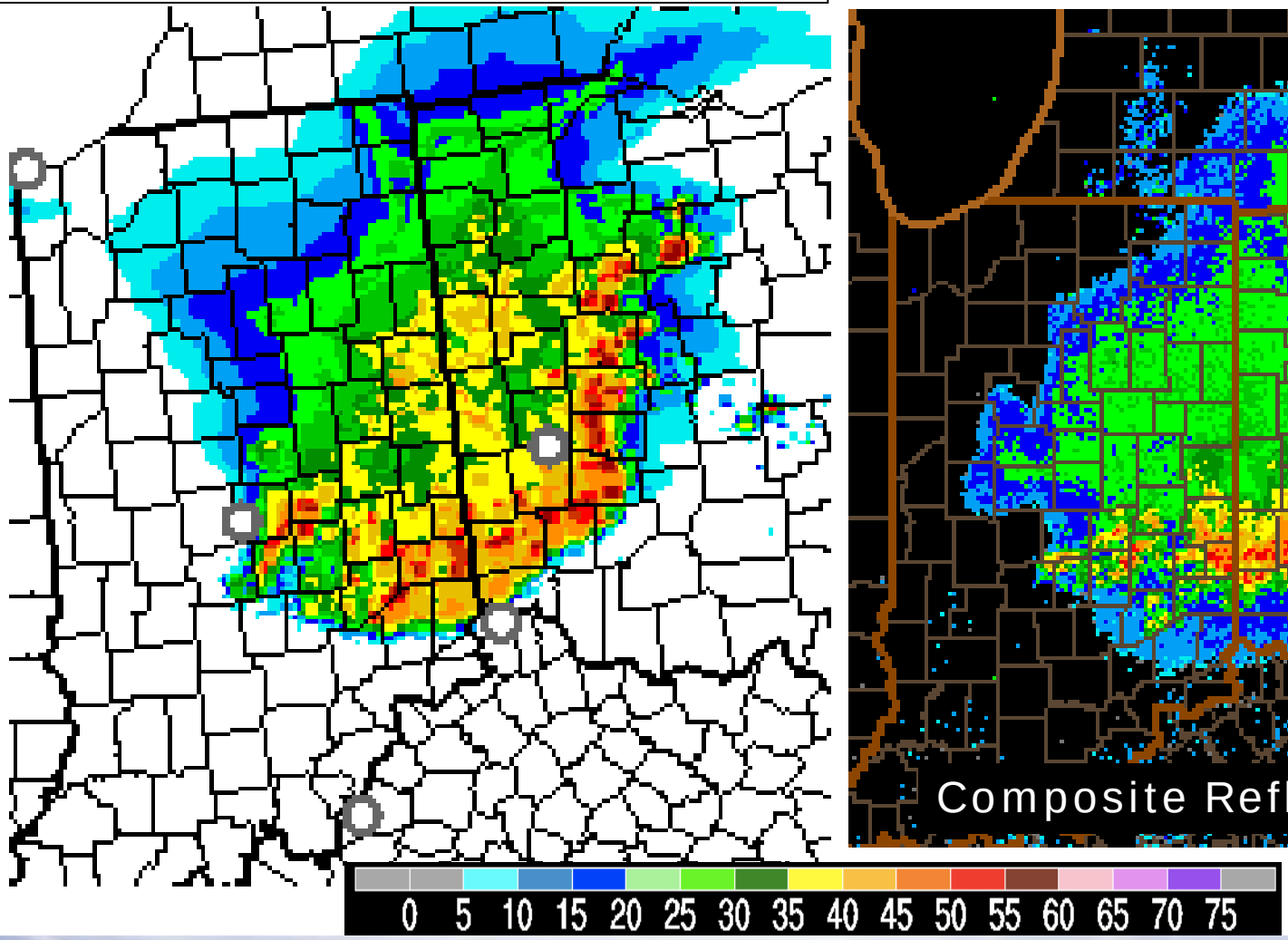


HRRR 15 UTC 29 June 2012

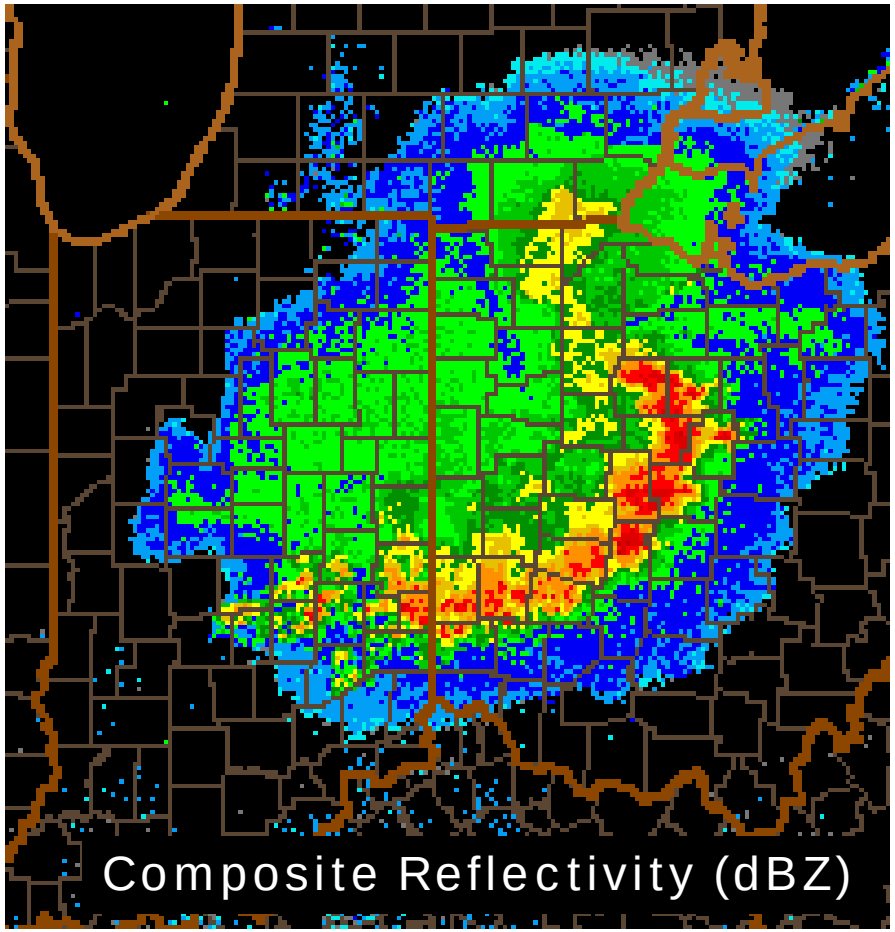


HRRR Real-Time Case Studies

HRRR 6h forecast –21z 29 June
Composite Reflectivity (dBZ)

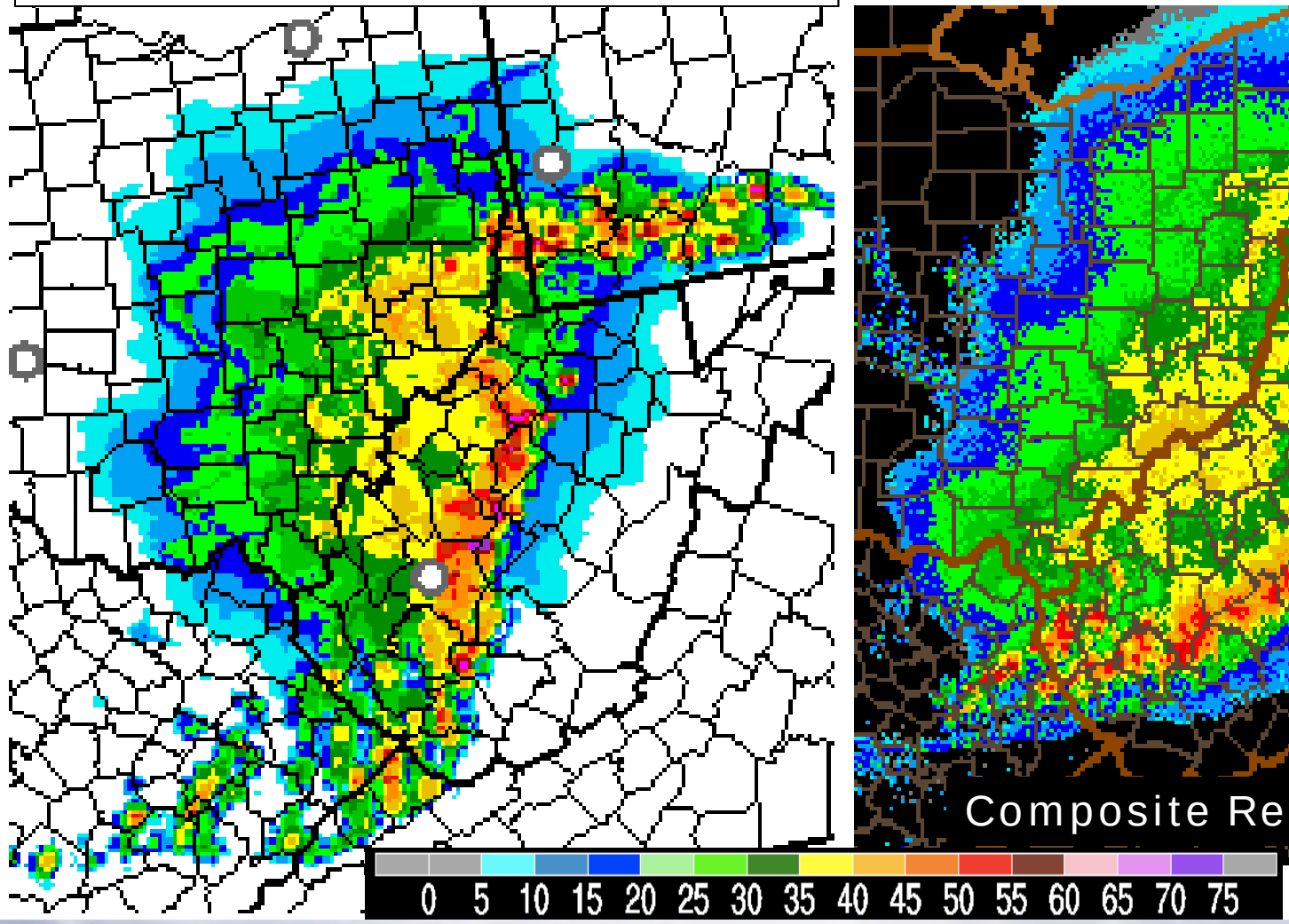


Radar Observed – 21z 29 June 2012

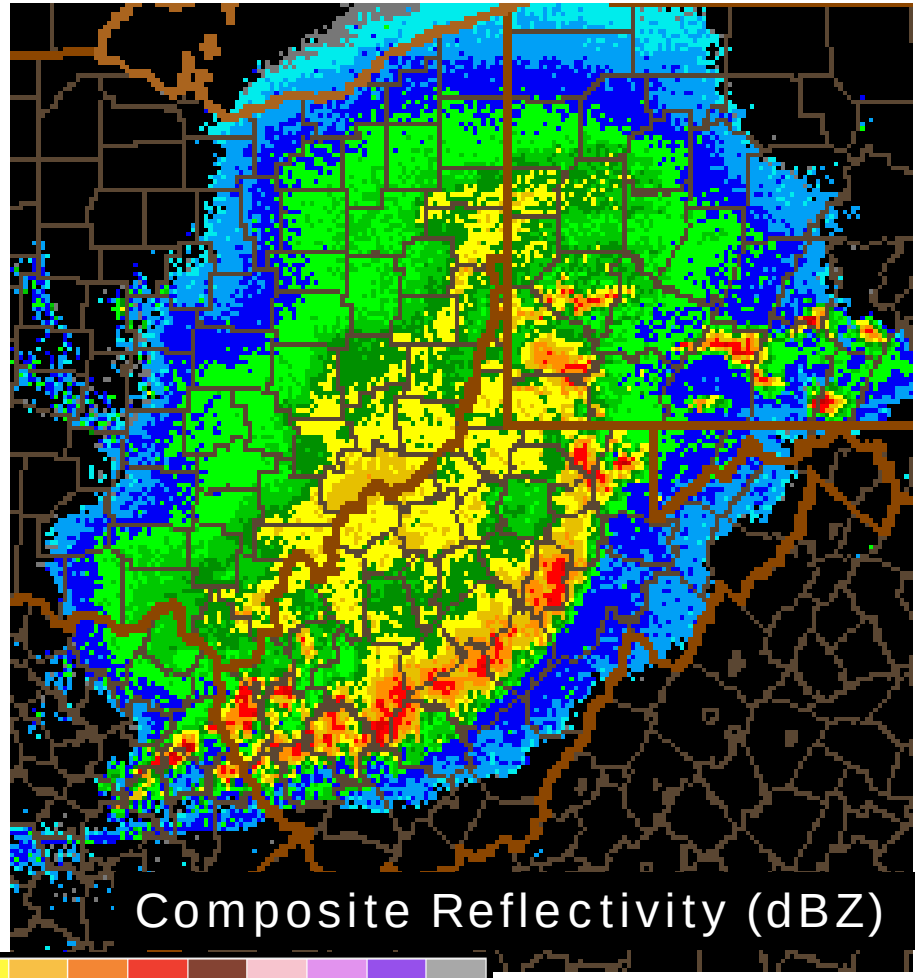


HRRR Real-Time Case Studies

HRRR 9h forecast –00z 30 June
Composite Reflectivity (dBZ)

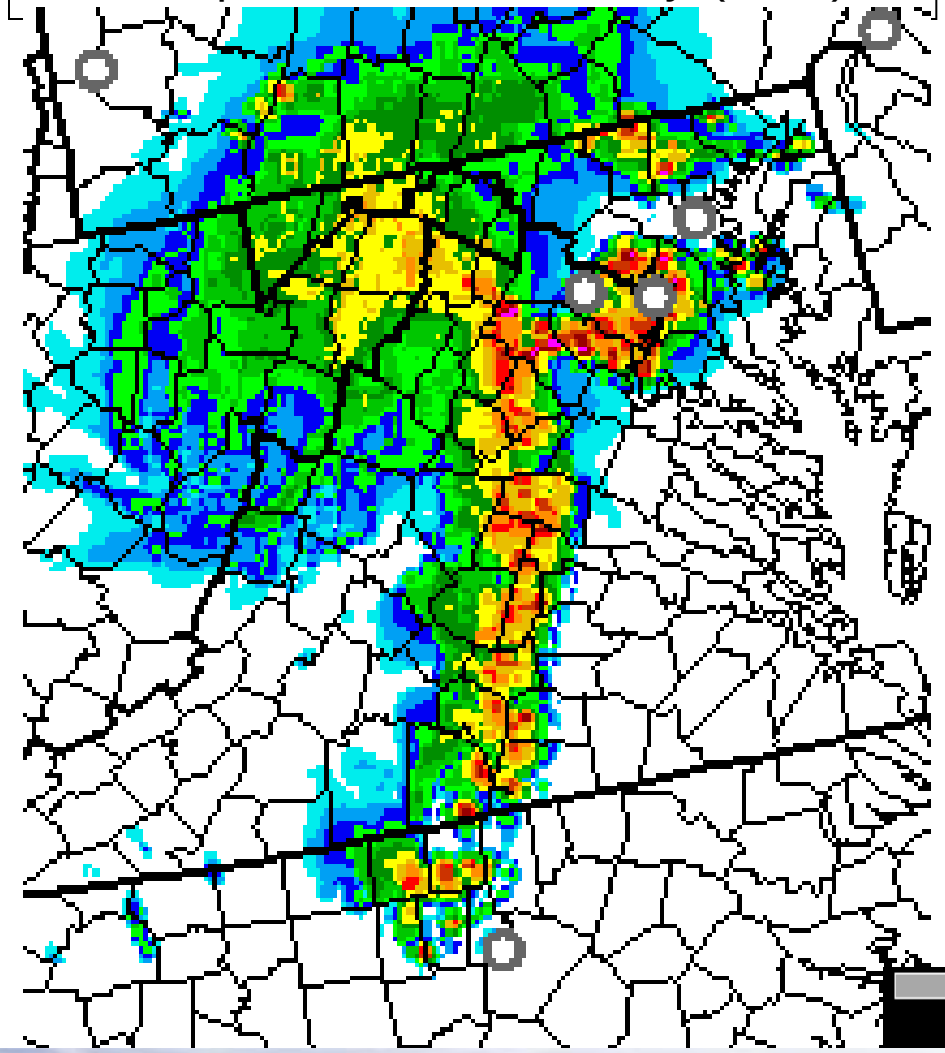


Radar Observed – 21z 29 June 2012

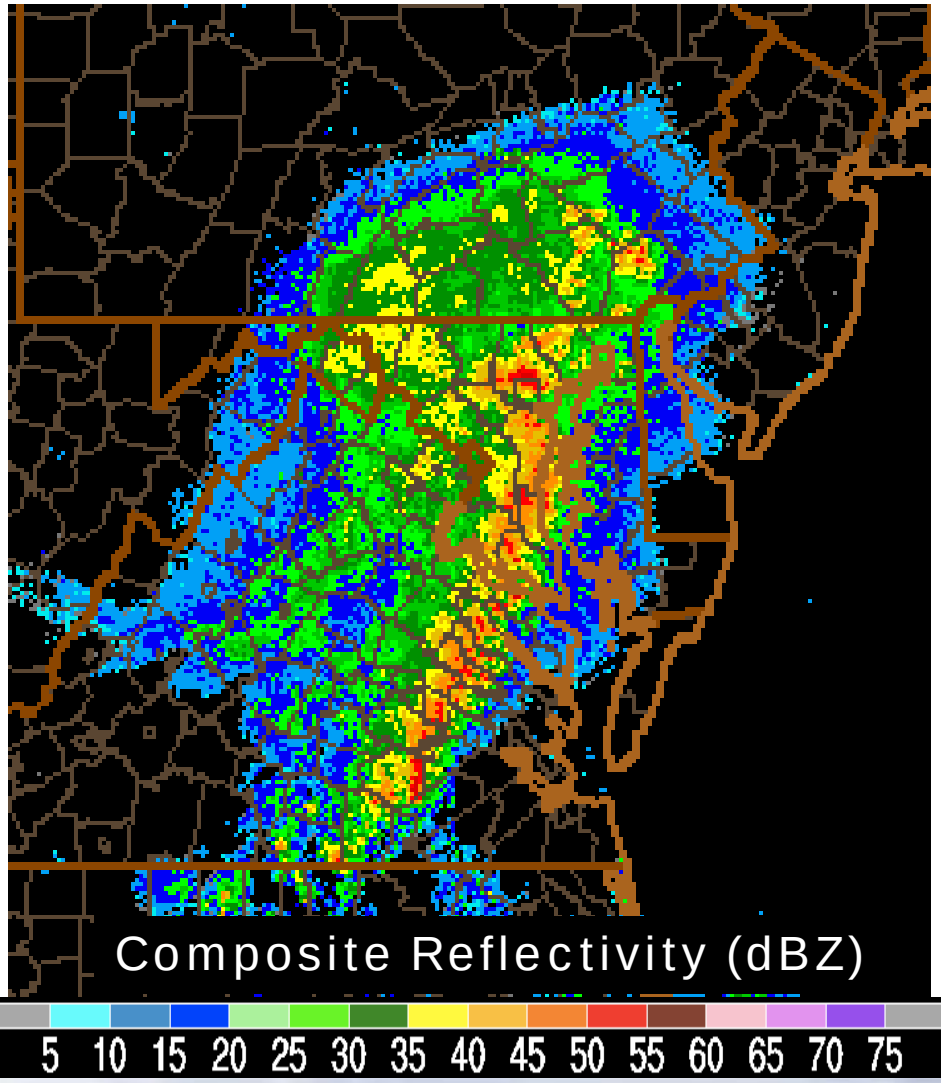


HRRR Real-Time Case Studies

HRRR 12h forecast –03z 30 June
Composite Reflectivity (dBZ)

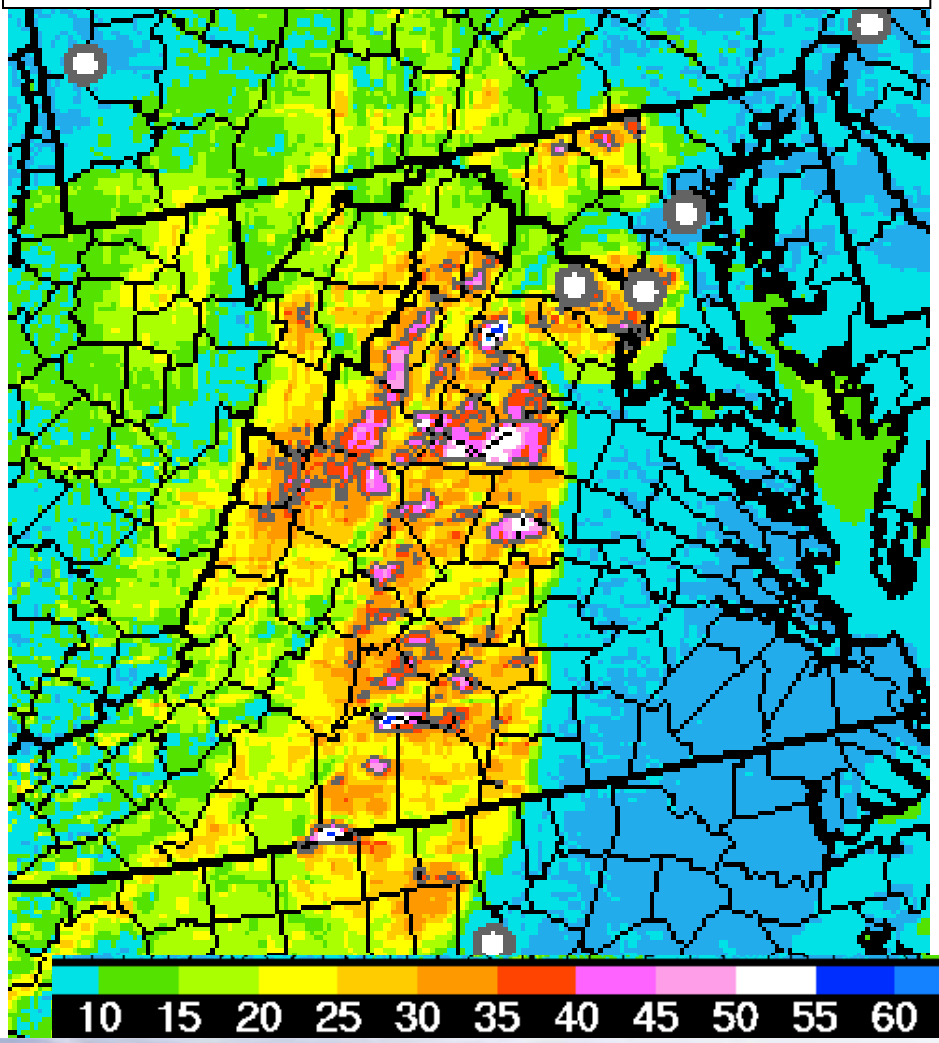


Radar Observed – 03z 30 June 2012

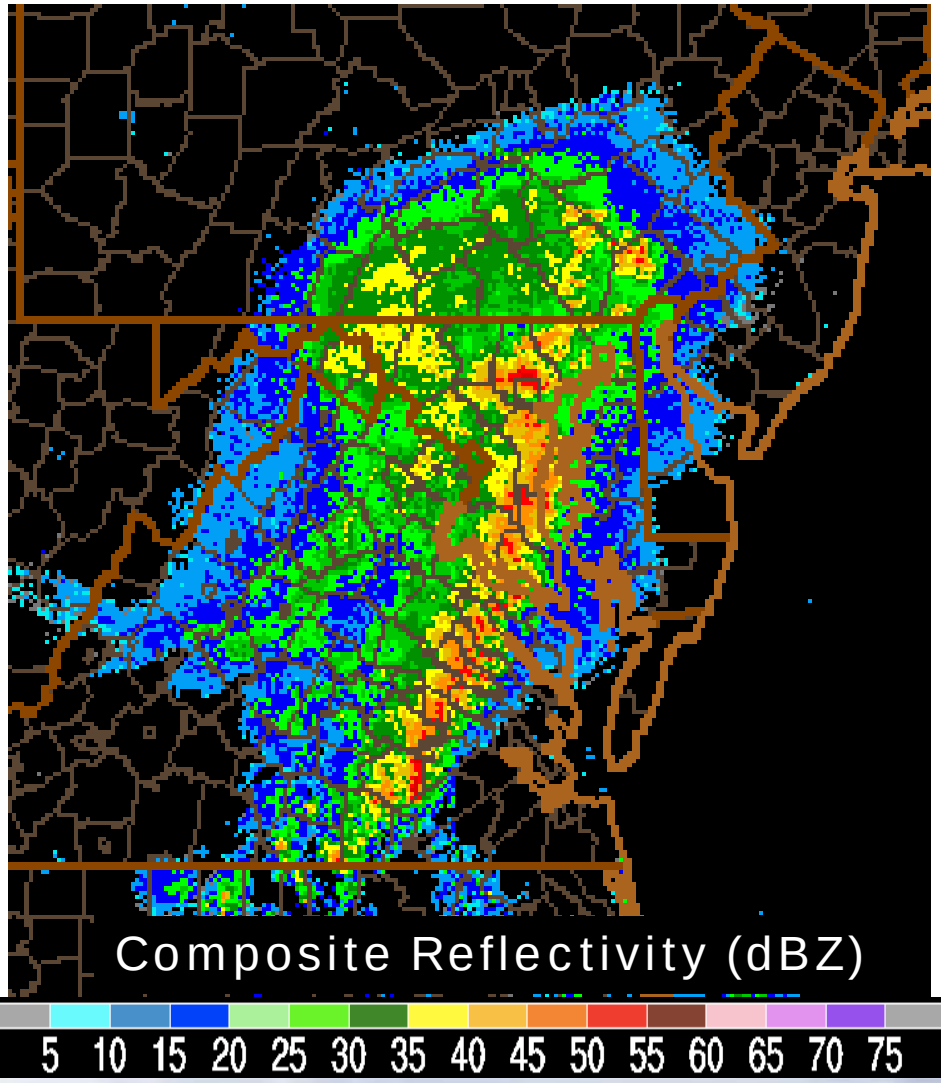


HRRR Real-Time Case Studies

HRRR 12h forecast –03z 30 Jun
max 10m wind speed (kts)



Radar Observed – 03z 30 June 2012



Verification of RAP-ESRL vs HRRR

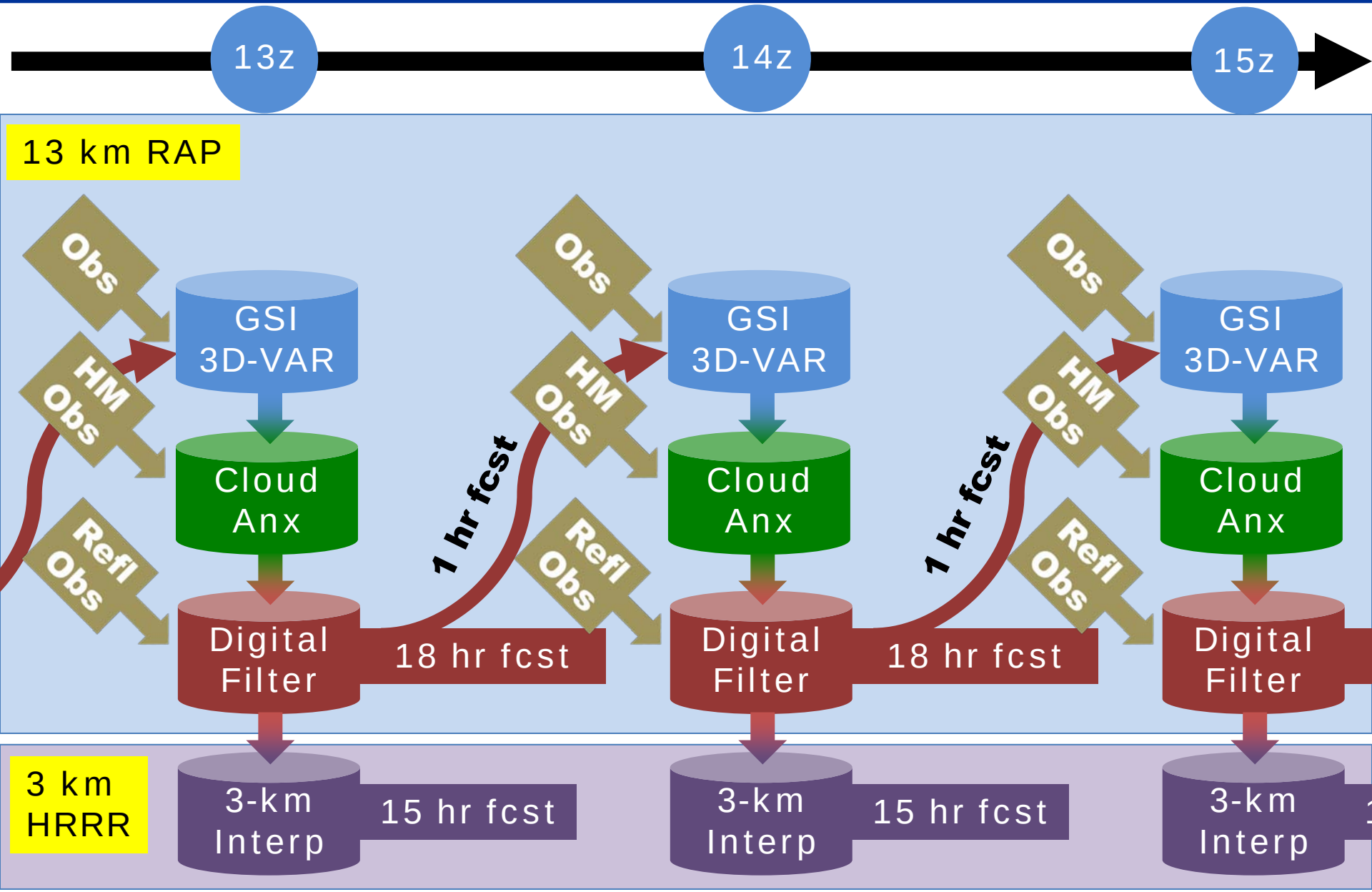
Cold Season (29 Jan 2012 – 31 Mar 2012) HRRR vs RAP												
Lead Time	Clouds		Precip (13 km)		Reflectivity (40 km)		Upper-Air			Surface		
	Ceiling < 500 ft	Vis < 0.5 mile	> 0.1 inch	> 1.0 inch	25 dBZ	35 dBZ	Temp	RH	Wind	Temp	Dewpt	Wind
3-hr	HRRR	HRRR	Equal	RAP	Equal	HRRR	HRRR	Equal	RAP	HRRR	RAP	HRRR
6-hr	HRRR	HRRR			HRRR	HRRR	HRRR	Equal	RAP	HRRR	Equal	HRRR
12-hr	HRRR	HRRR			HRRR	HRRR	HRRR	RAP	RAP	HRRR	HRRR	HRRR

Warm Season (01 May 2012 – 31 Aug 2012) HRRR vs RAP												
Lead Time	Clouds		Precip (13 km)		Reflectivity (40 km)		Upper-Air			Surface		
	Ceiling < 500 ft	Vis < 0.5 mile	> 0.1 inch	> 1.0 inch	25 dBZ	35 dBZ	Temp	RH	Wind	Temp	Dewpt	Wind
3-hr	HRRR	HRRR	Equal	RAP	HRRR	HRRR	HRRR	RAP	RAP	Equal	RAP	Equal
6-hr	HRRR	Equal			HRRR	HRRR	HRRR	RAP	RAP	Equal	Equal	Equal
12-hr	HRRR	RAP			HRRR	HRRR	HRRR	RAP	RAP	HRRR	Equal	Equal

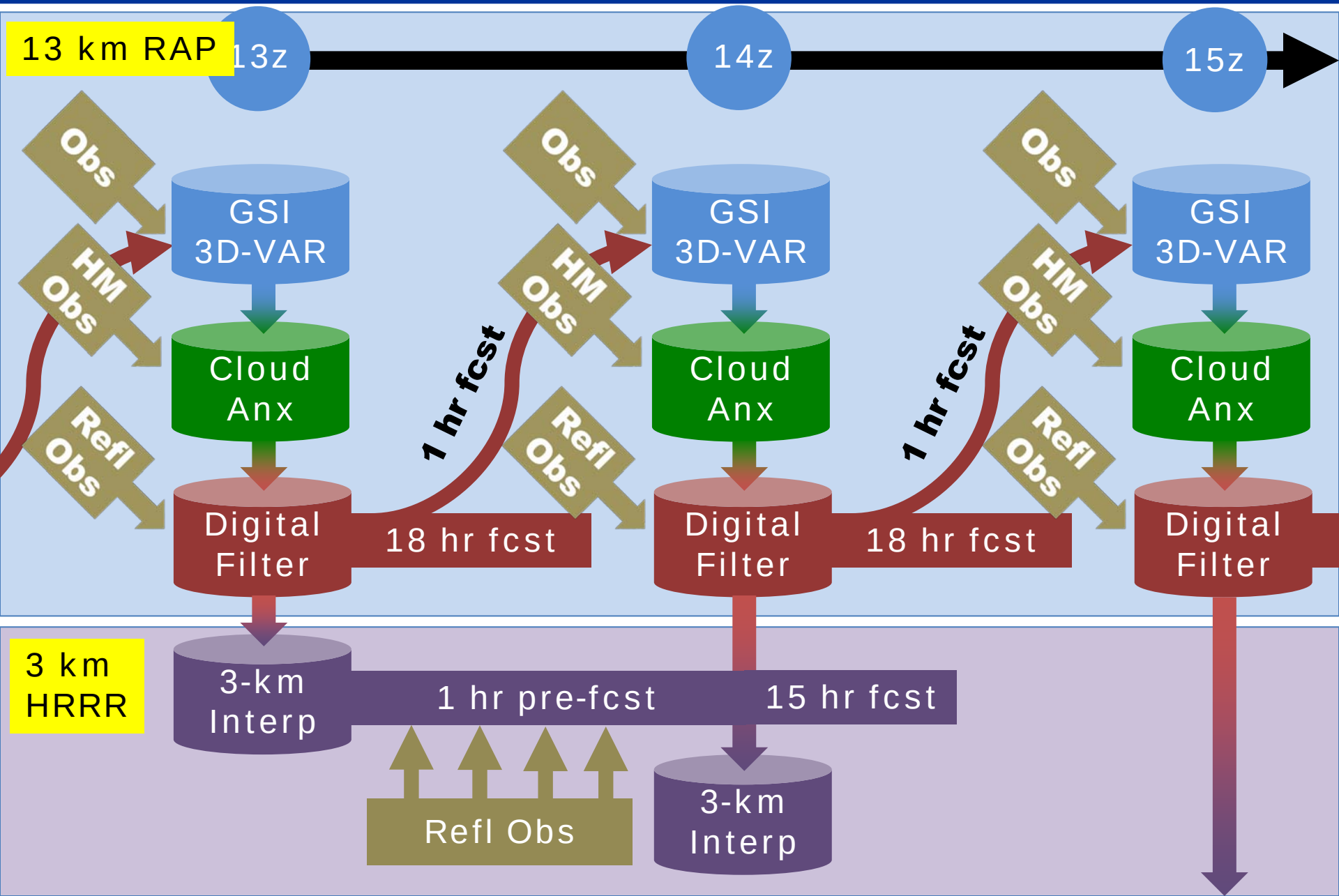
RAP and HRRR Changes 2013

	Model	Data Assimilation
RAP-ESRL (13 km)	WRFv3.4.1+ incl. physics changes (convection, snow-radiation fix) Numerics changes: 6th-order diffusion near surface Physics changes: MYNN PBL scheme 9-layer RUC LSM (from 6-layer) Modified roughness length RRTMG short/longwave radiation Thompson microphysics update	Merge with GFS trunk GFS ensemble background error cov Cloud fraction assimilation Full column cloud building Radiance bias correction Reduced observation error (sharper inversions, low-level thermo)
HRRR (3 km)	WRFv3.4.1+ incl. physics changes (convection, snow-radiation fix) Numerics changes: 6th-order diffusion near surface Physics changes: MYNN PBL scheme 9-layer RUC LSM (from 6-layer) Modified roughness length RRTMG short/longwave radiation Thompson microphysics update	3 km/15 min reflect assimilation 3 km cloud cycling 3 km land-surface cycling

Hourly HRRR Initialization from RAP

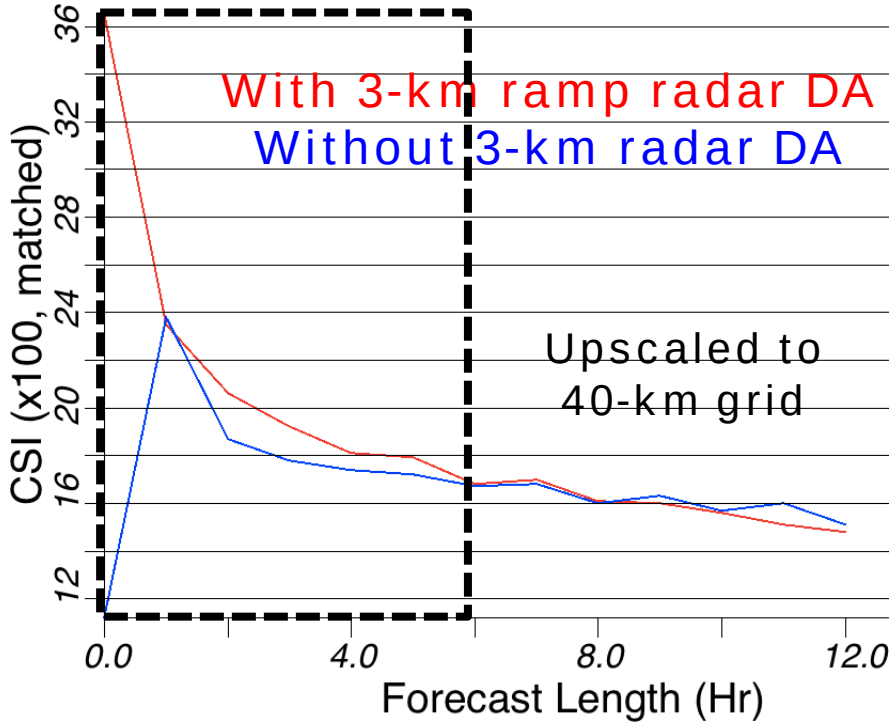


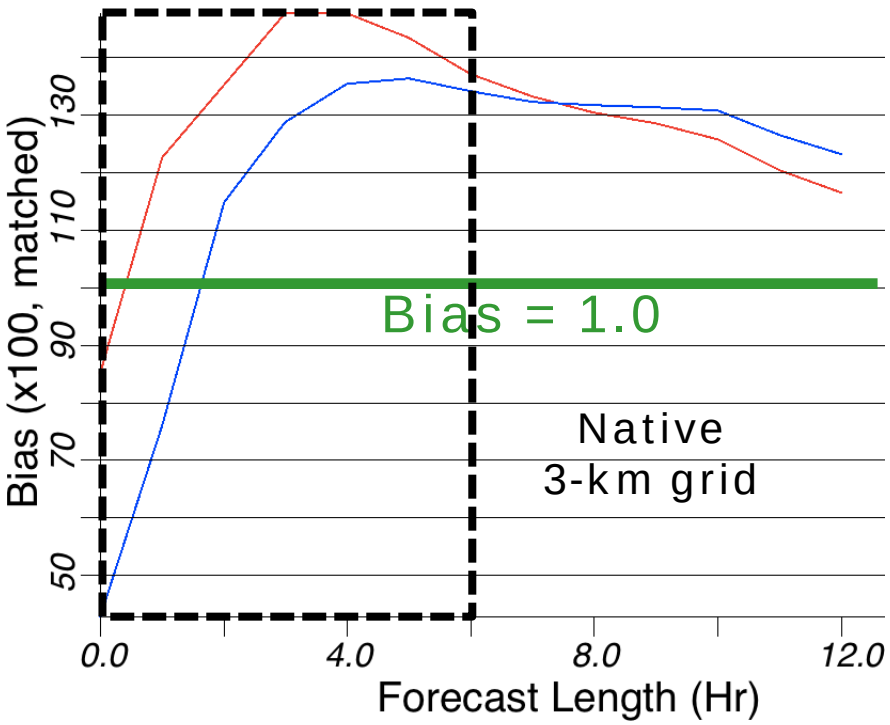
Experiment #1: Cycled Refl at 3 km



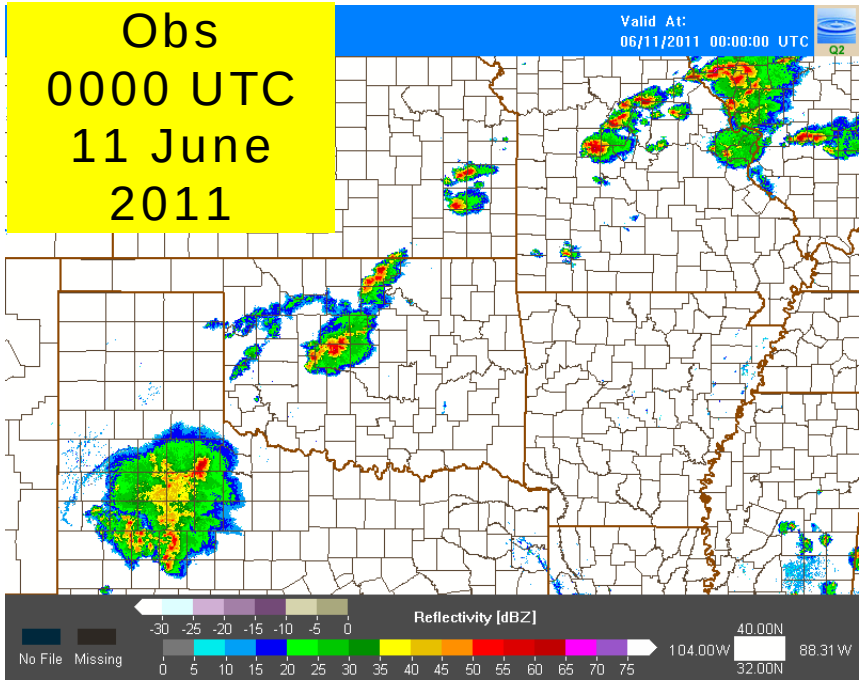
HRRR Reflectivity Verification

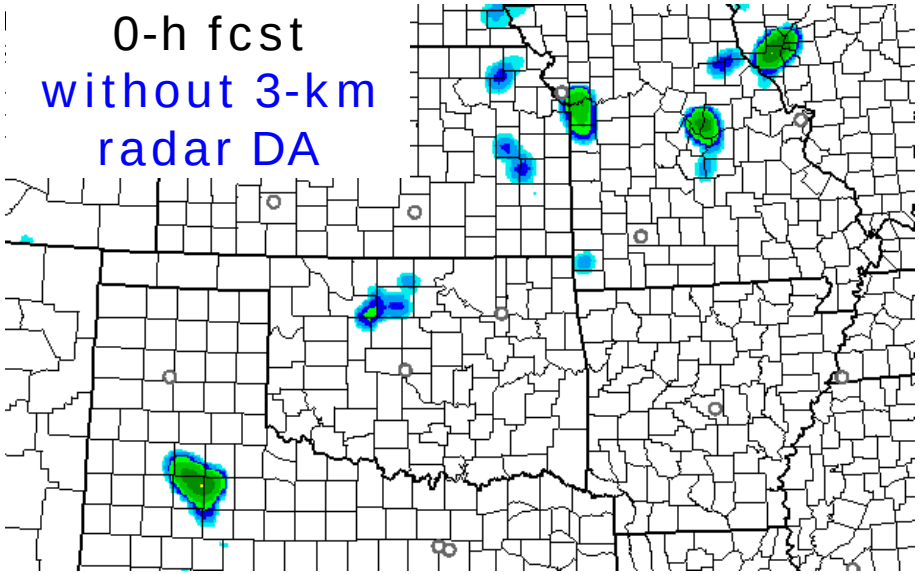
14-day retrospective period June 2011 (160 runs)
Forecasts every 2 hours
> 25 dBZ Composite Reflectivity
Eastern half of US

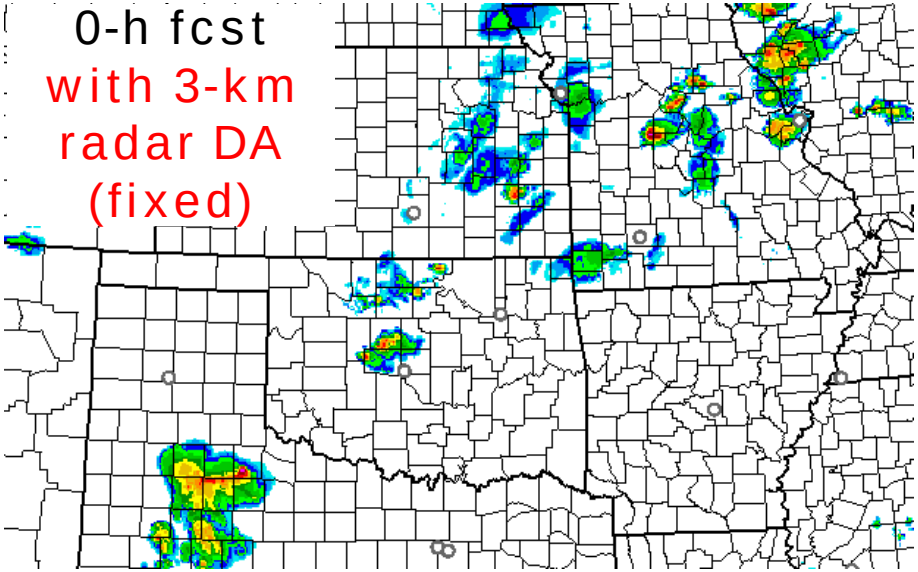


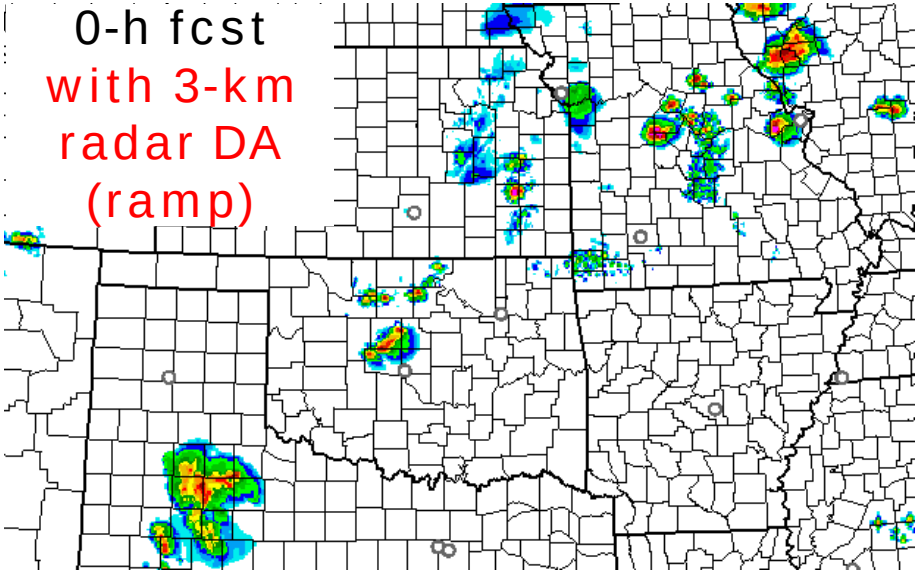


Greatly improved CSI and BIAS between 0-1 fcst hr
Benefit persists until 4 hrs, similar skill after

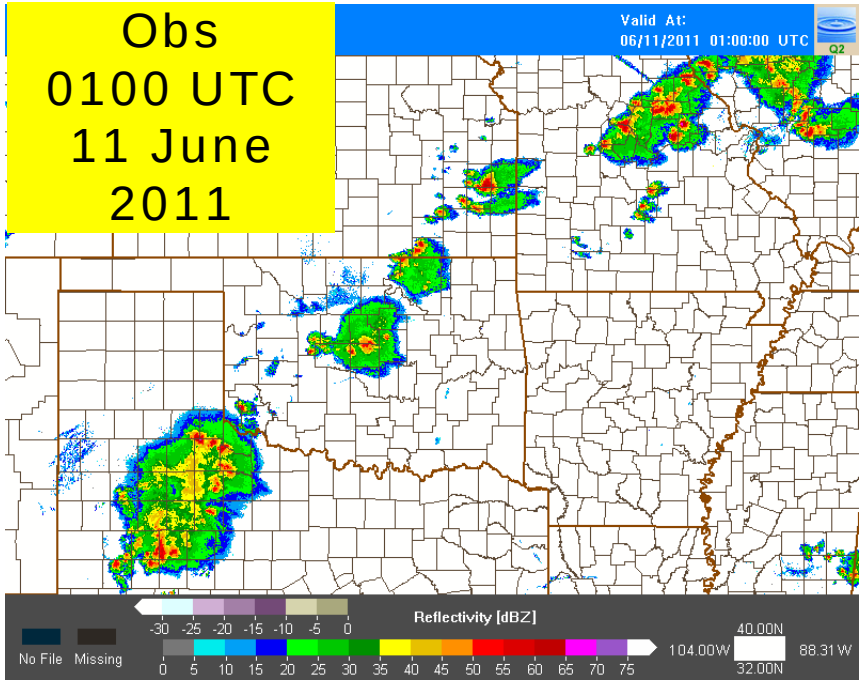


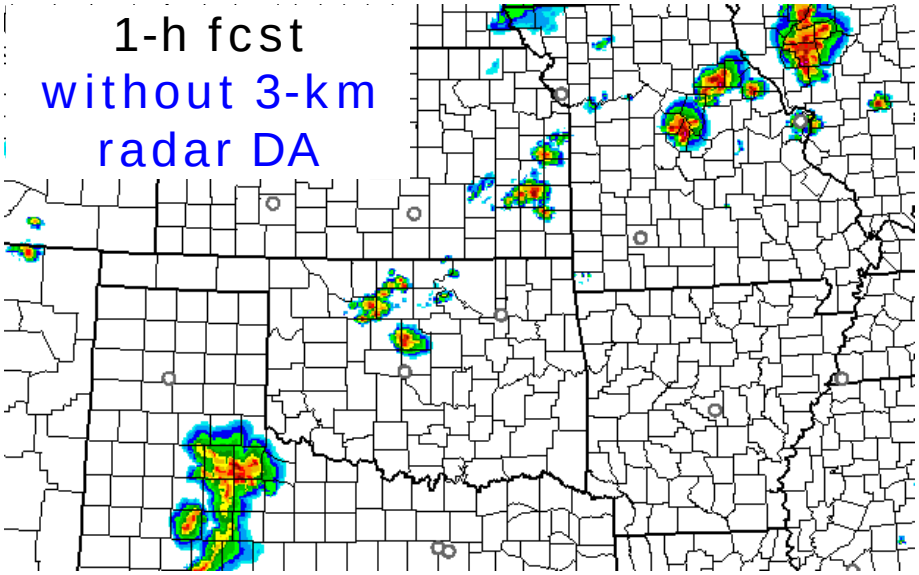


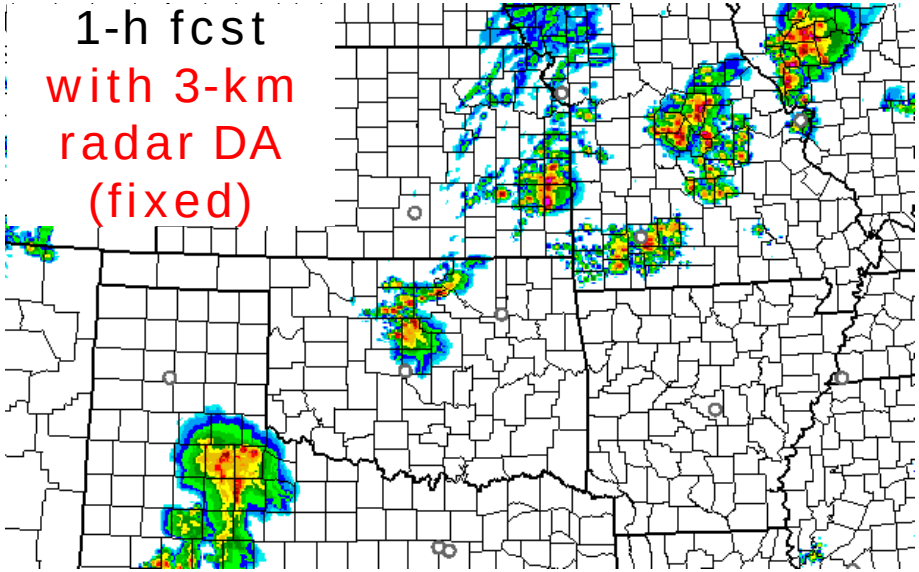


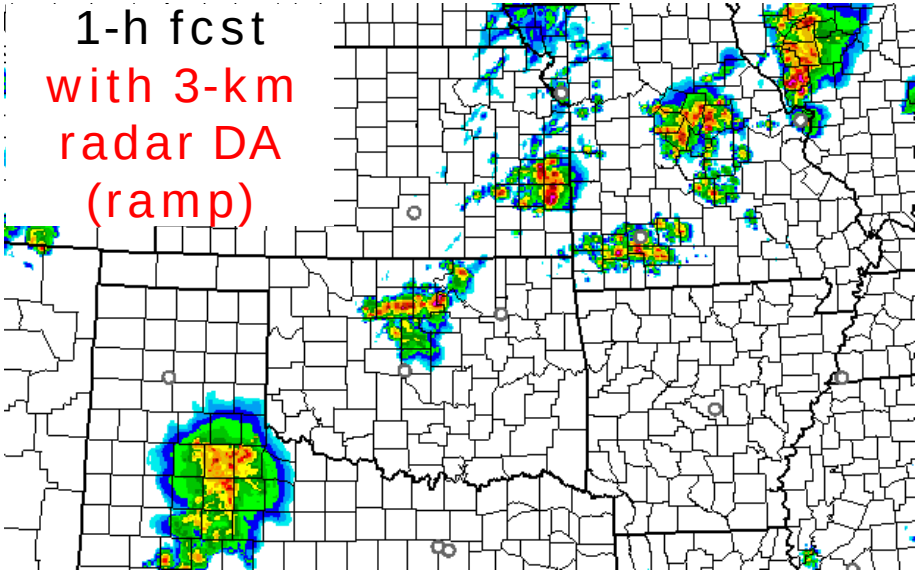


Benefit from pre-forecast 3-km model integration









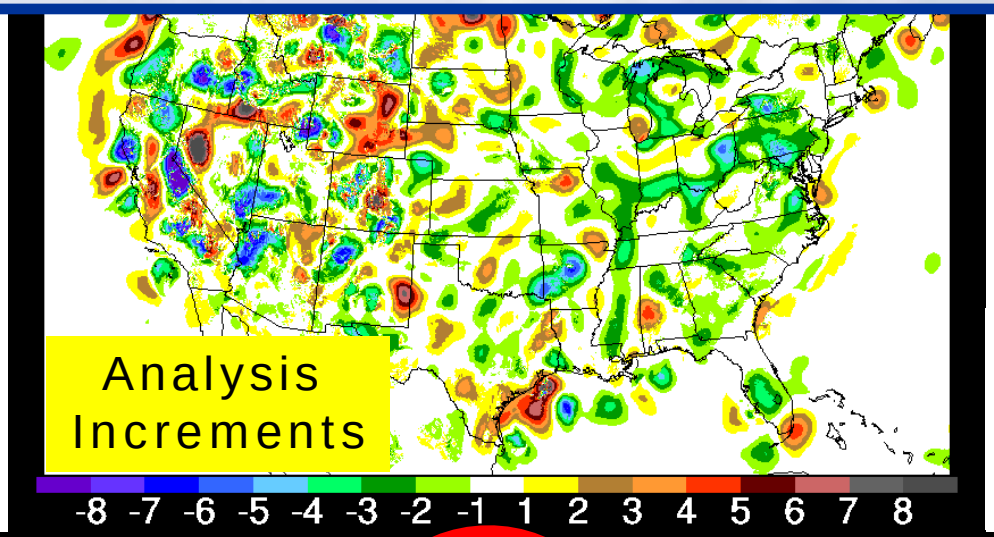
Convective systems more mature even by 1-hr

HRRR Real-Time Exper Products

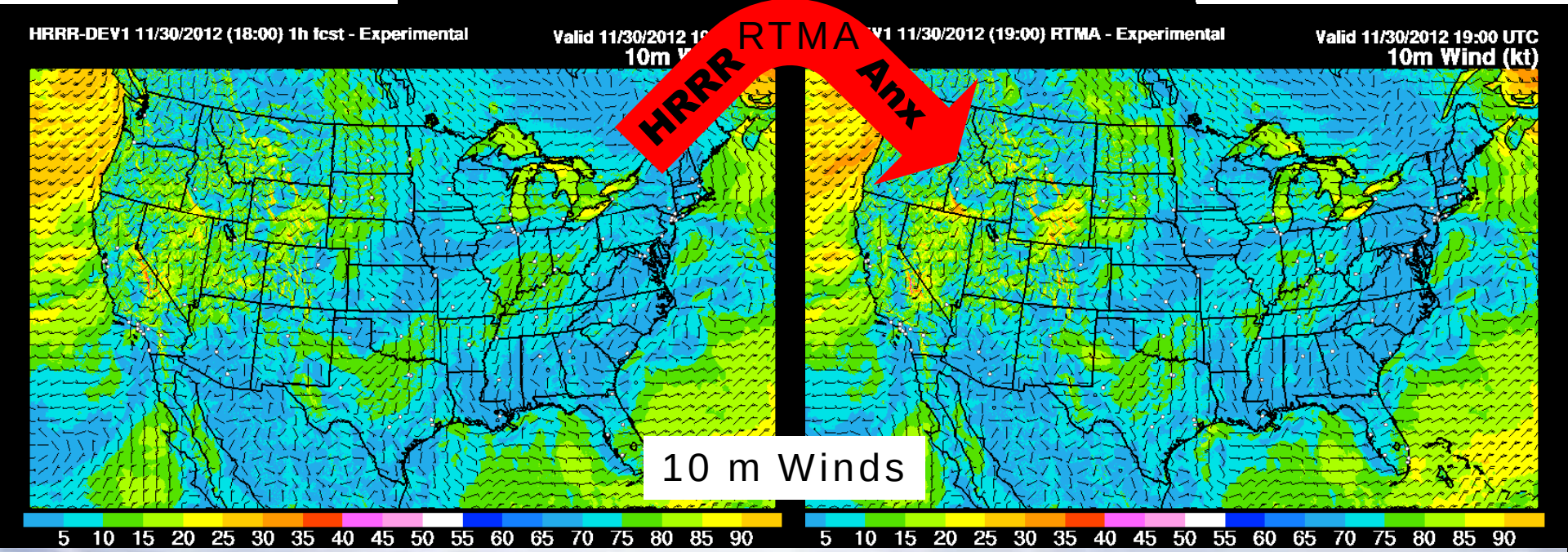
	Background	Radar Specification of Hydrometeors	Scale at which Latent Heating is applied	Dimensionality	Updated
2012 HRRR model initialization	13-km RAP	No	13-km	3-D	Hourly
2013 HRRR model initialization	13-km RAP	No	**3km in 60min spin-up (also using 13km radar-LH-DFI)**	3-D	Hourly
Rapidly Updating Analysis (RUA-HRRR)	3-km HRRR 1 hr fcst	**Yes**	None	3-D	Hourly
Real-Time Meso Analysis (RTMA-HRRR)	3-km HRRR 1 hr fcst	No	None	2-D	**Hourly (15 min planned)**
Time-Lagged HRRR (HCPF)	3-km HRRR Fcsts	No	Same as HRRR	2-D	Hourly

3-km HRRR RTMA

1-hr HRRR Fcst
(Background)
Valid 19 UTC
30 Nov 2012

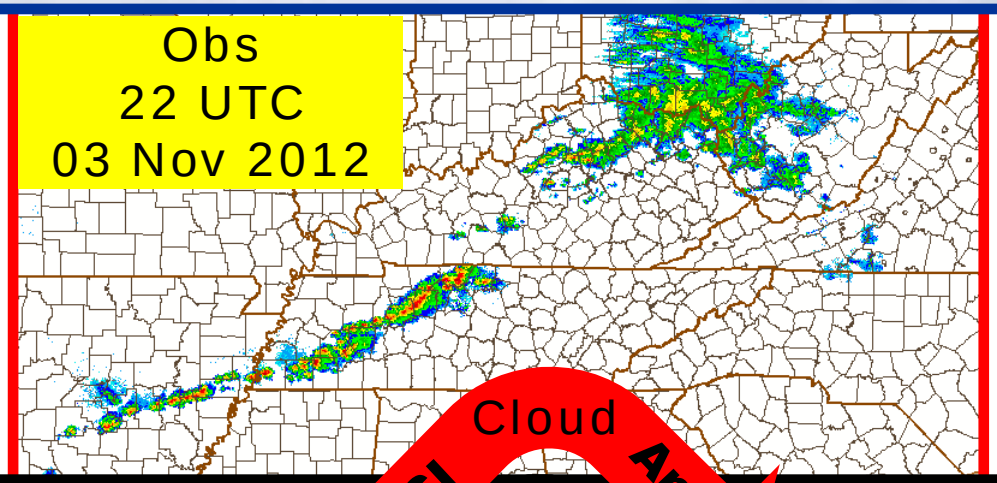


0-hr HRRR Anal
Valid 19 UTC
30 Nov 2012

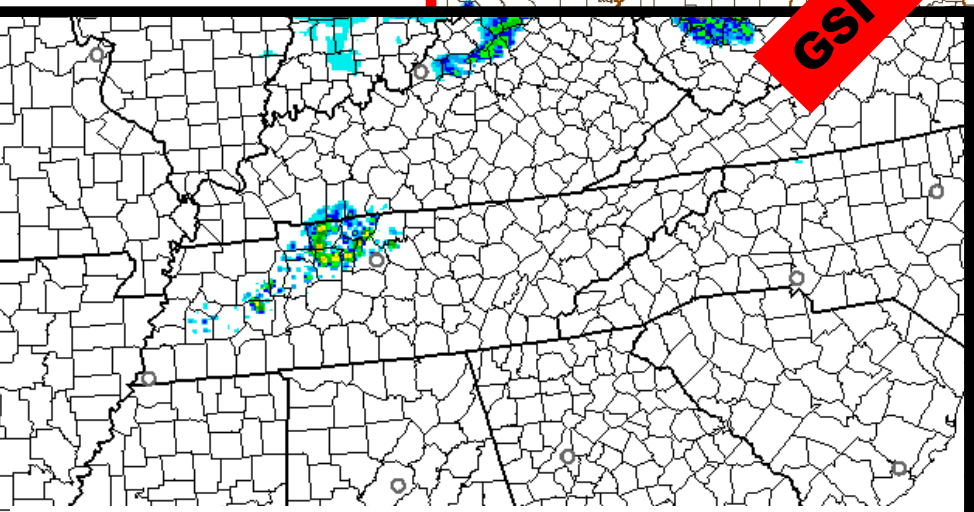


3-km HRRR RUA

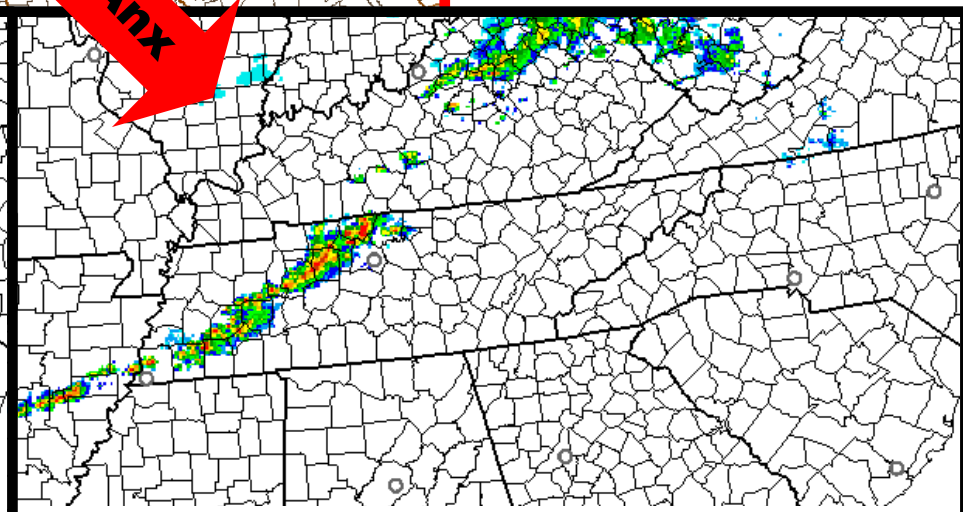
Rapidly Updating Analysis (RUA)



Specifies Hydrometeors From Radar Observations



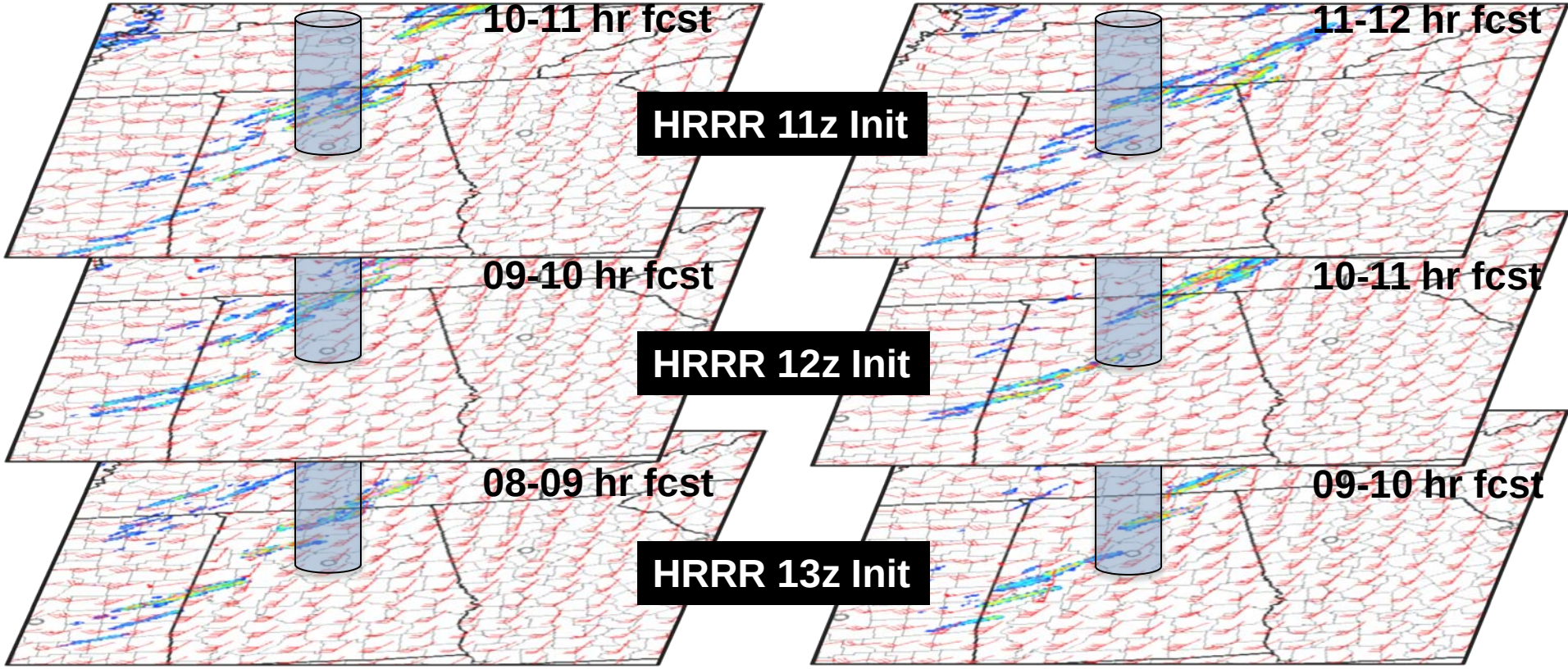
1-hr HRRR Forecast (Background)
Valid 22 UTC
03 November 2012



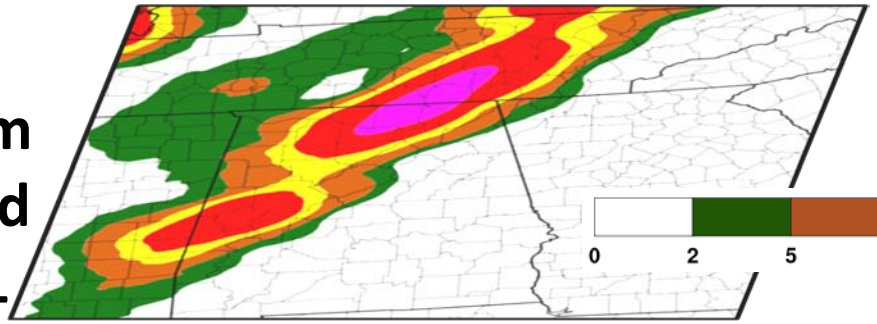
0-hr HRRR Analysis (RUA)
Valid 22 UTC
03 November 2012

Time-Lagged (TL) Ensemble

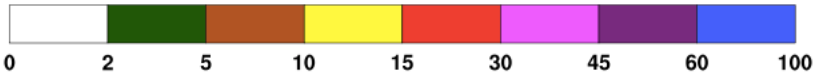
Forecasts valid 21-22z 27 April 2011 | **Forecasts valid 22-23z 27 April 2011**



All six forecasts combined to form probabilities valid 22z 27 April 2011

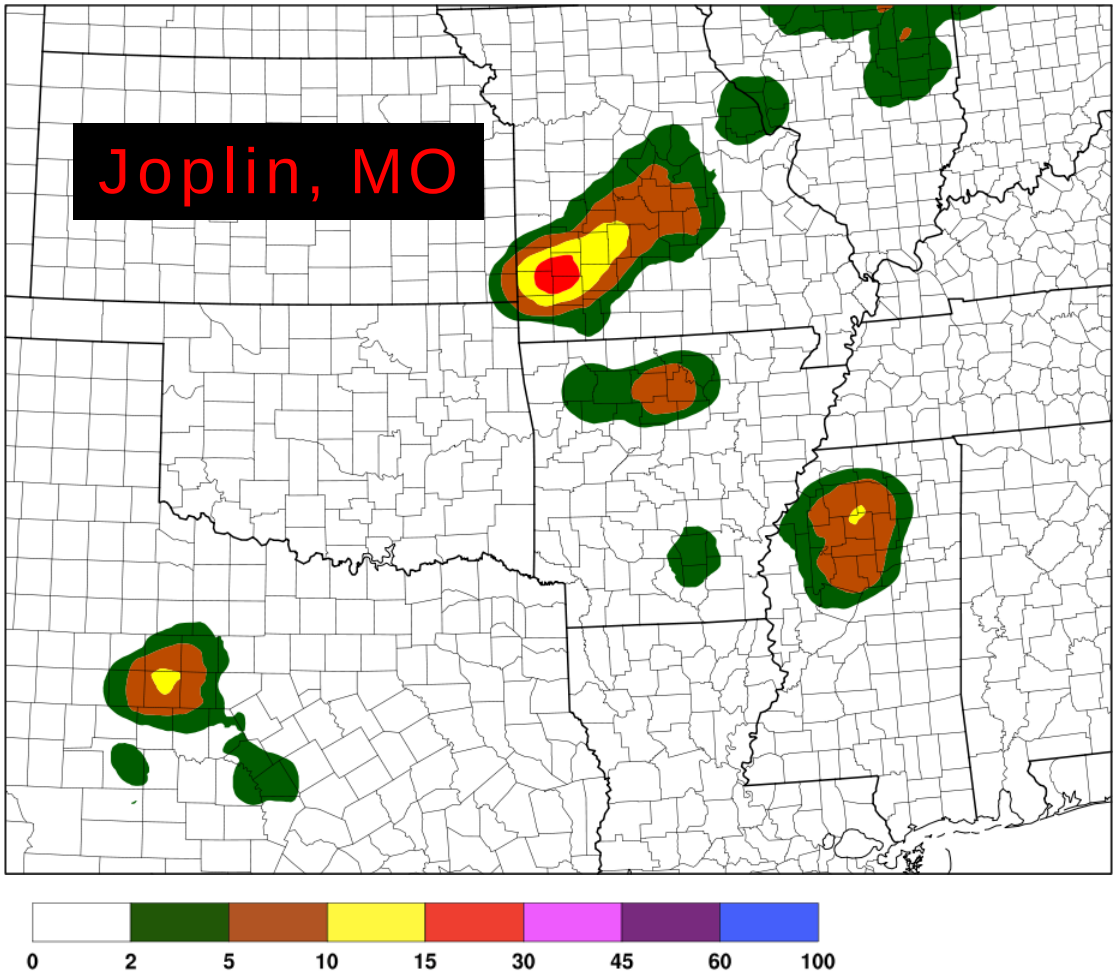


Spatial radius 45 km
Time radius 1 hr
UH threshold 25 m^2/s^2



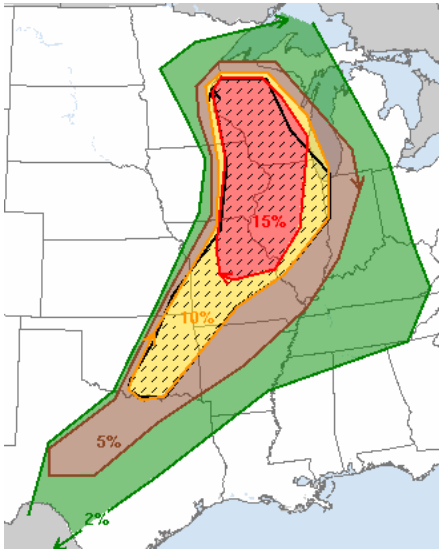
TL Example: 22 May 2011

13z + 11hr fcst
Valid 00z 23 May 2011

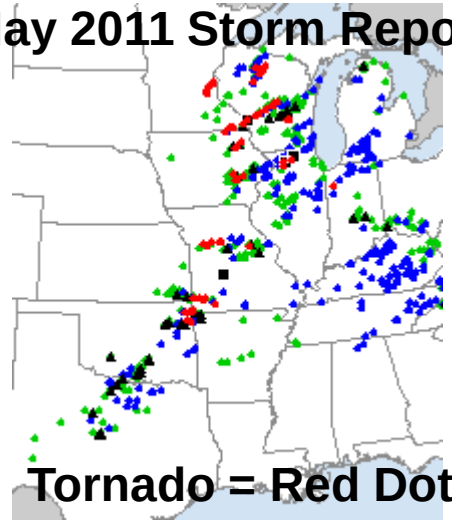


Tornadic Storm Probability (%)

1300z SPC Tornado Probability



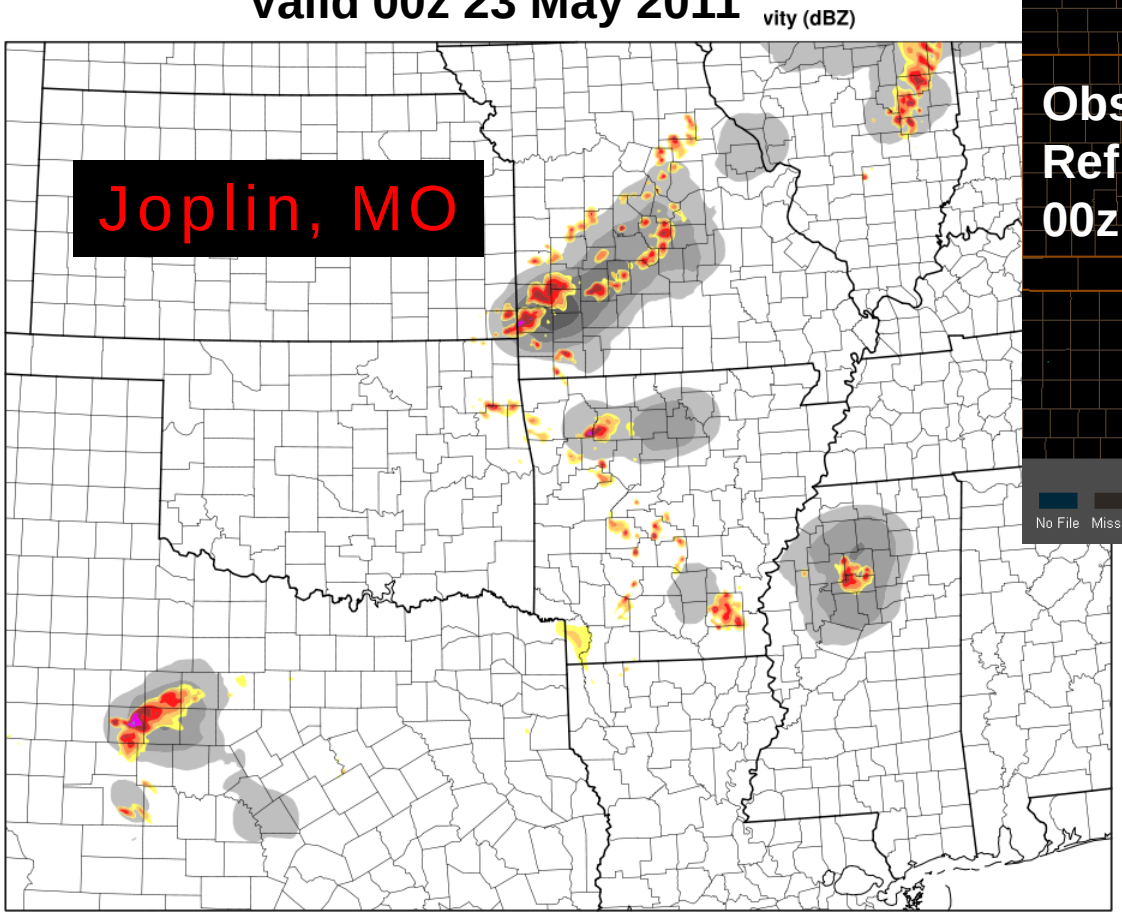
22 May 2011 Storm Reports

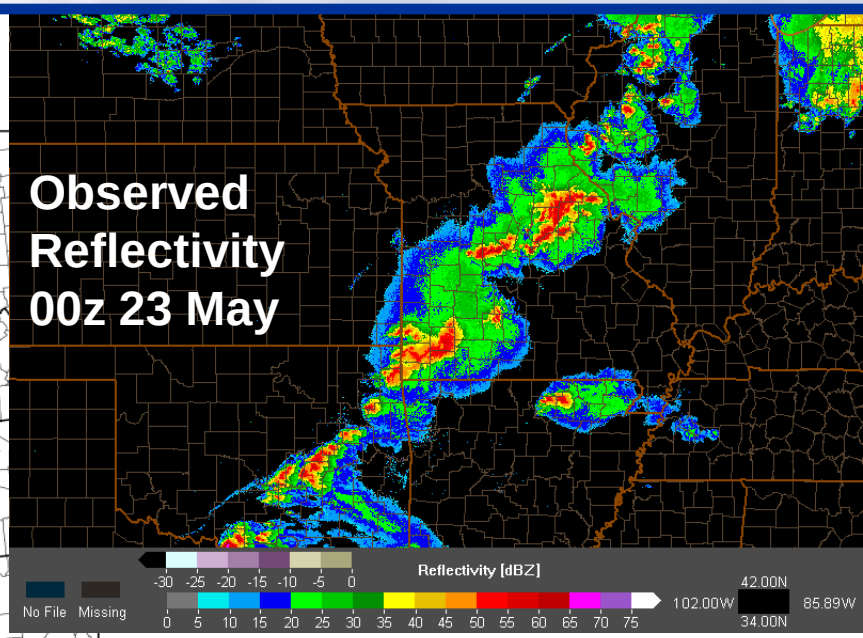


Tornado = Red Dots

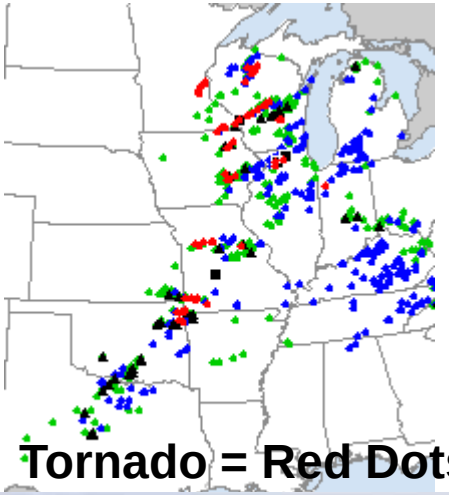
TL Example: 22 May 2011

13z + 11hr fcst
Valid 00z 23 May 2011



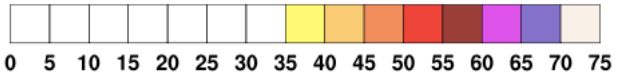


22 May 2011 Storm Reports



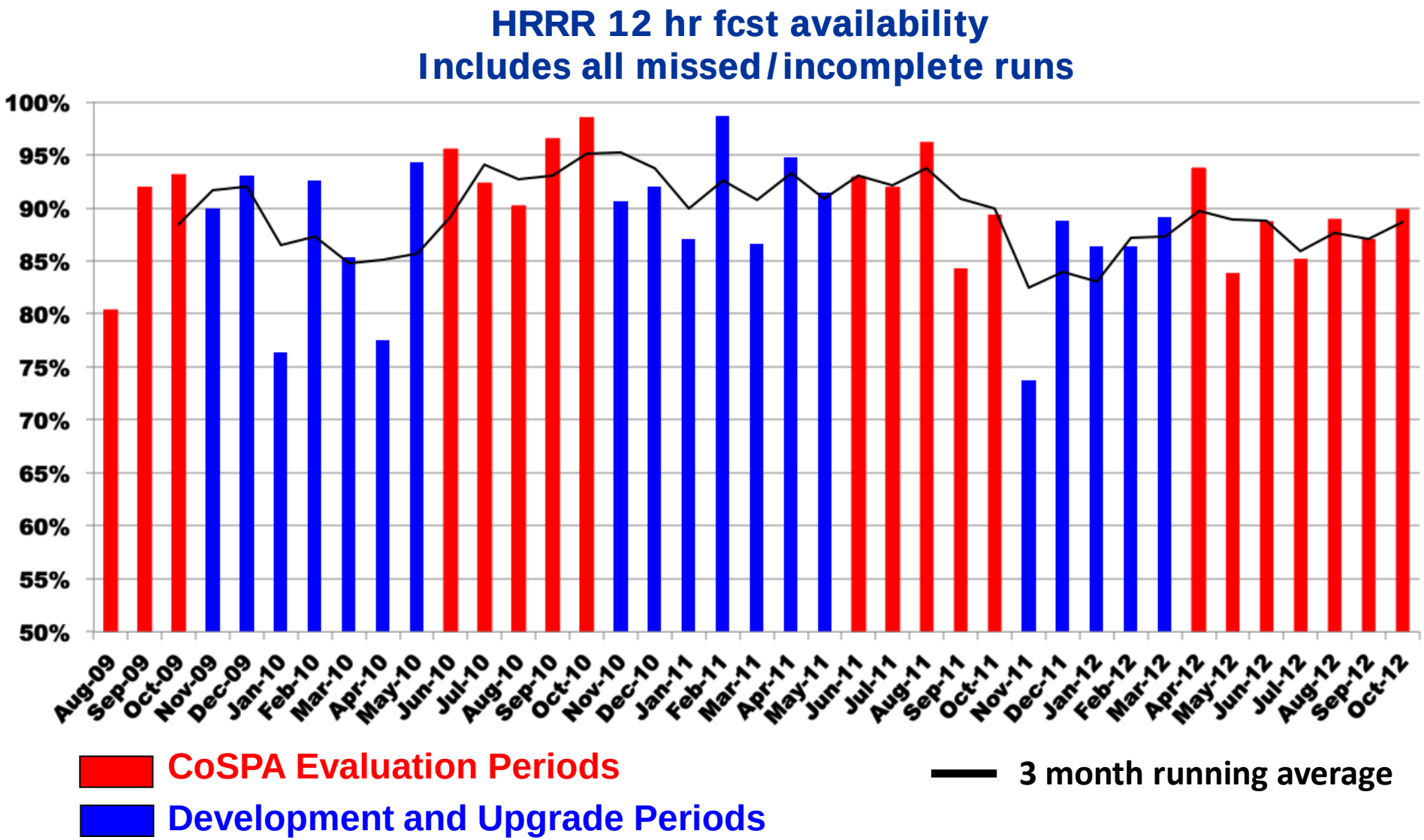
Tornado = Red Dots

Tornadic Storm Probability (%)

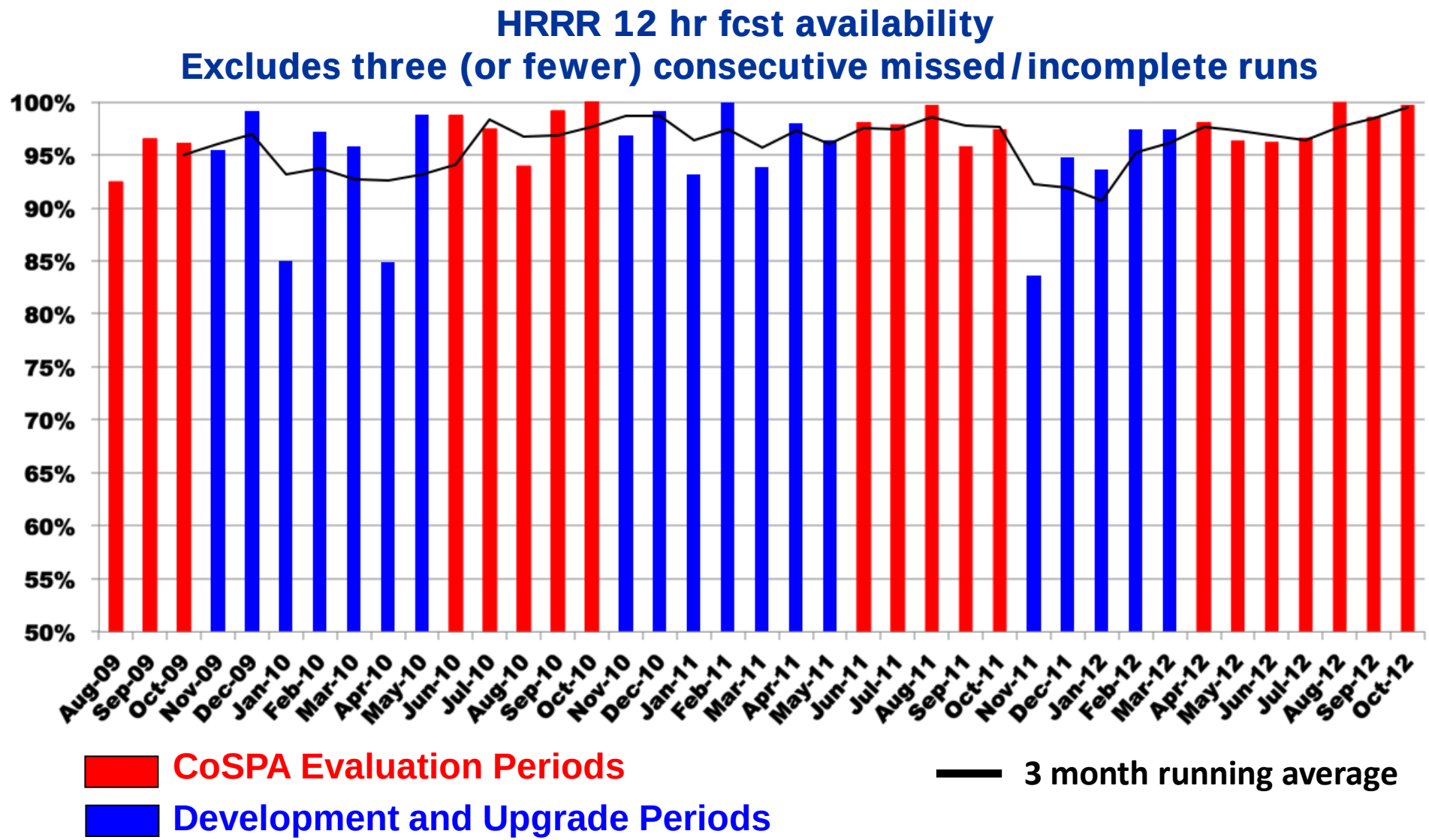


Reflectivity (dBZ)

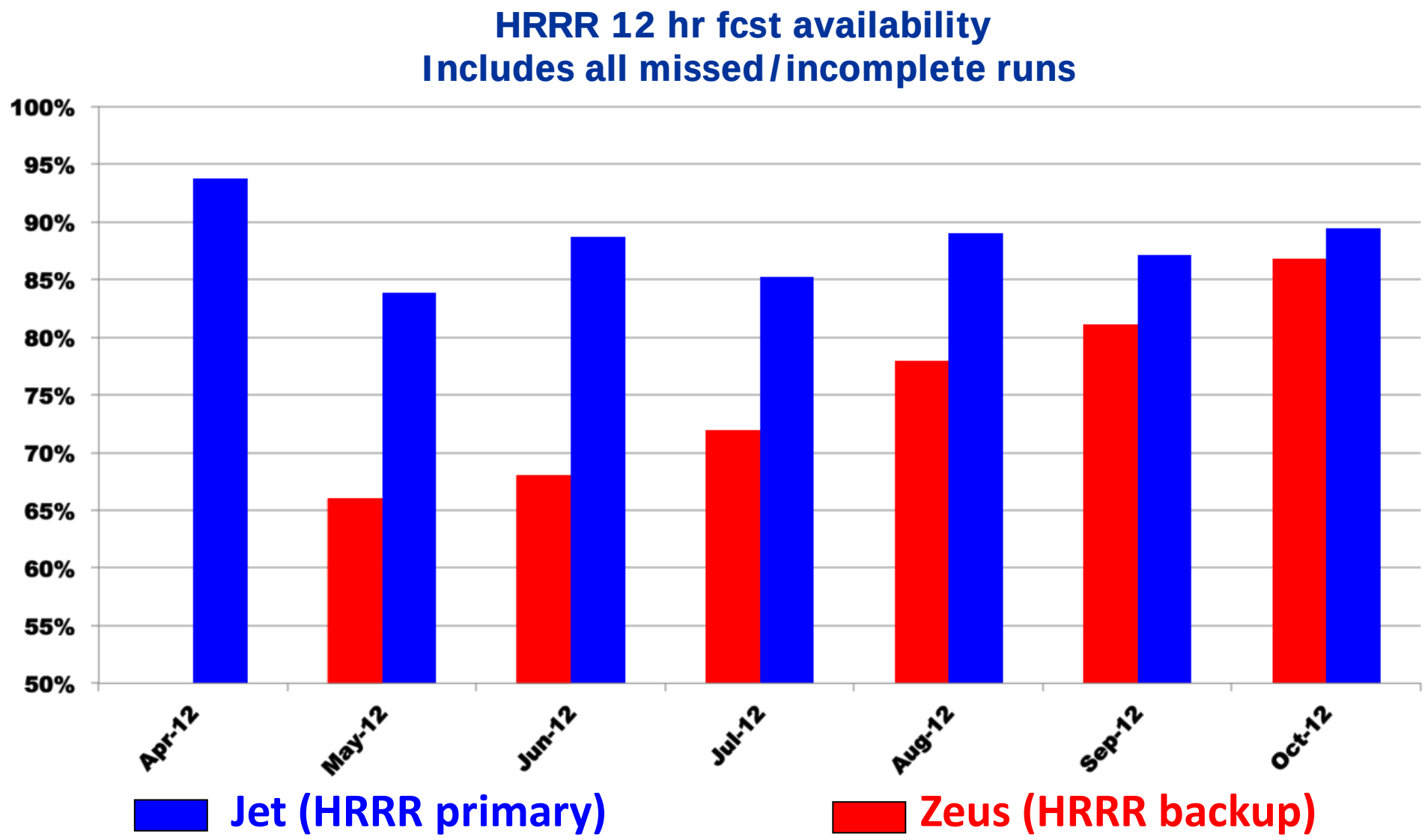
HRRR Reliability



HRRR Reliability



HRRR Reliability



HRRR Transition to NCEP

- **Current – 1 computer running HRRR**
  - NOAA/ESRL – Boulder
  - Current reliability: 97% for last 12h months (allowing up to 3h gaps)
- **2013-14 – 2 computers running HRRR – interim solution**
  - Boulder – computer 1
  - Fairmont, WV – computer 2
  - Expected reliability to increase further to 98.5-99% via coordination of downtimes for Boulder vs. Fairmont computers
- **Est. 2015 – NCEP running HRRR**
  - NOAA/NCEP computing budget – will allow no increase before 2015
- Conclusion: ***Interim HRRR computing for 2012-14 on 2 sites to provide "real-time experimental" HRRR from NOAA for NWS, FAA, DOE/energy users***

Summary and Plans

- **Moist bias reduced in 2012 RAP and HRRR**
  - Reduced false alarms, lower precipitation bias
  - GSI enhancements and WRF upgrade to v3.3.1
  - Reflectivity diagnostic consistent with microphysics
- **Science: Focus on 3-km assimilation for 2013**
  - 3-km variational analysis
  - 3-km non-variational cloud analysis
  - 3-km radar reflectivity data assimilation
- **Technical: Reduced latency for 2013 (2-3 hrs now)**
  - Approximate 1-hr reduction in execution time (1-2 hrs)
  - Faster post-processing with parallelization
  - Direct GRIB2 generation

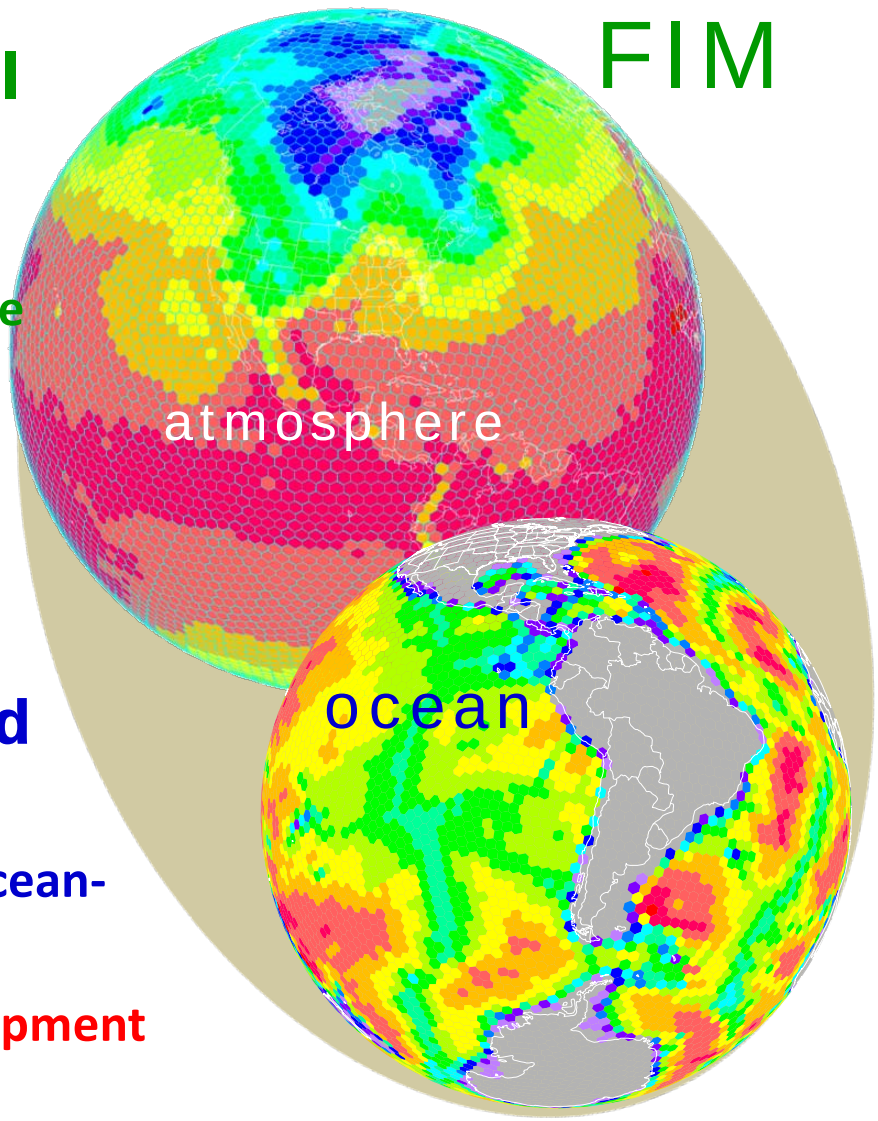
FIM Model Development – testing – http://fim.noaa.gov

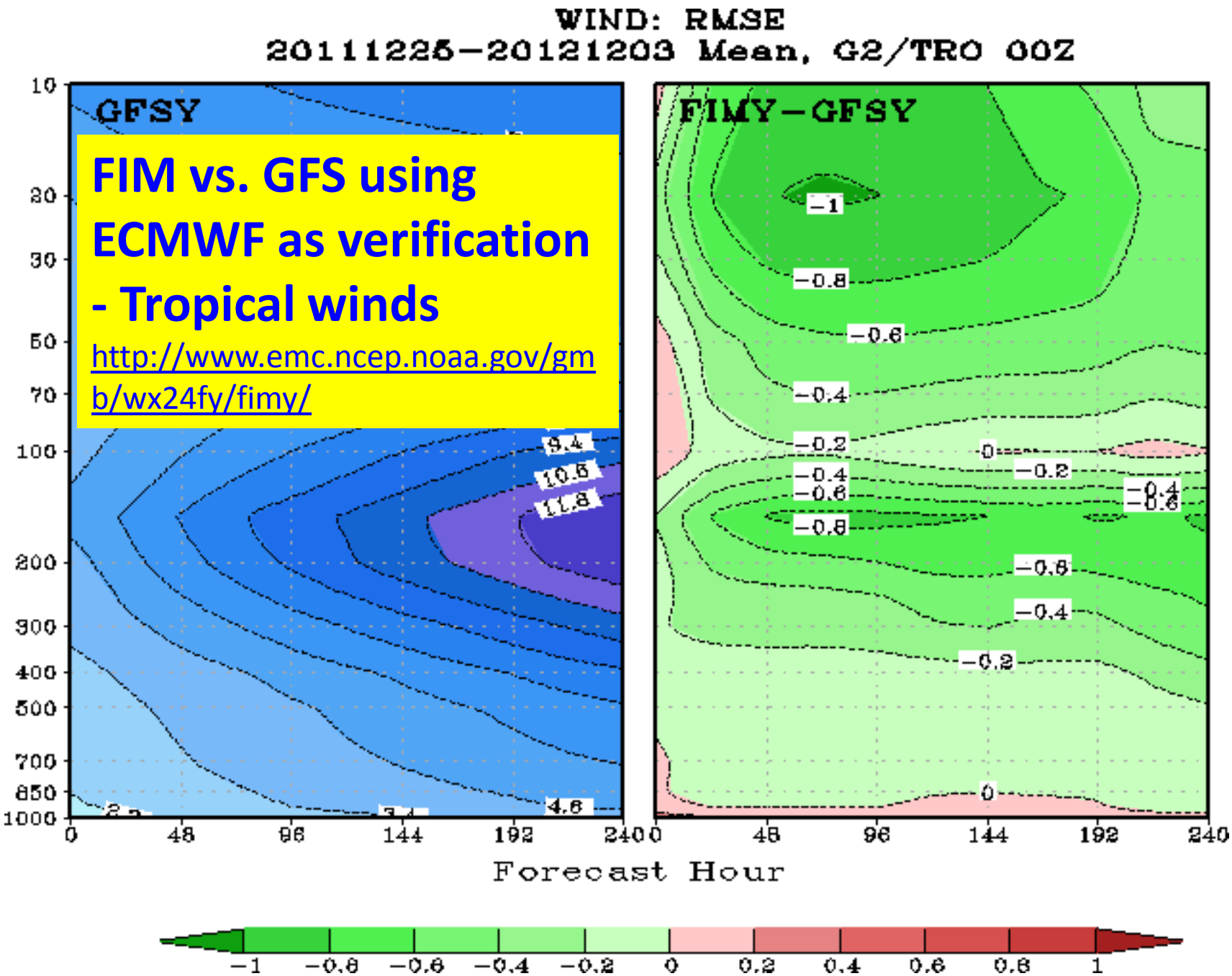
FIM – Flow-following finite volume Icosahedral Model

- "soccer-ball" grid design for uniform grid spacing
- Isentropic/sigma hybrid vertical coordinate
- New 7-14-day forecast twice daily
  - 15km, 30km, 60km
  - Grids to NCEP for evaluation
- Real-time experimental at ESRL

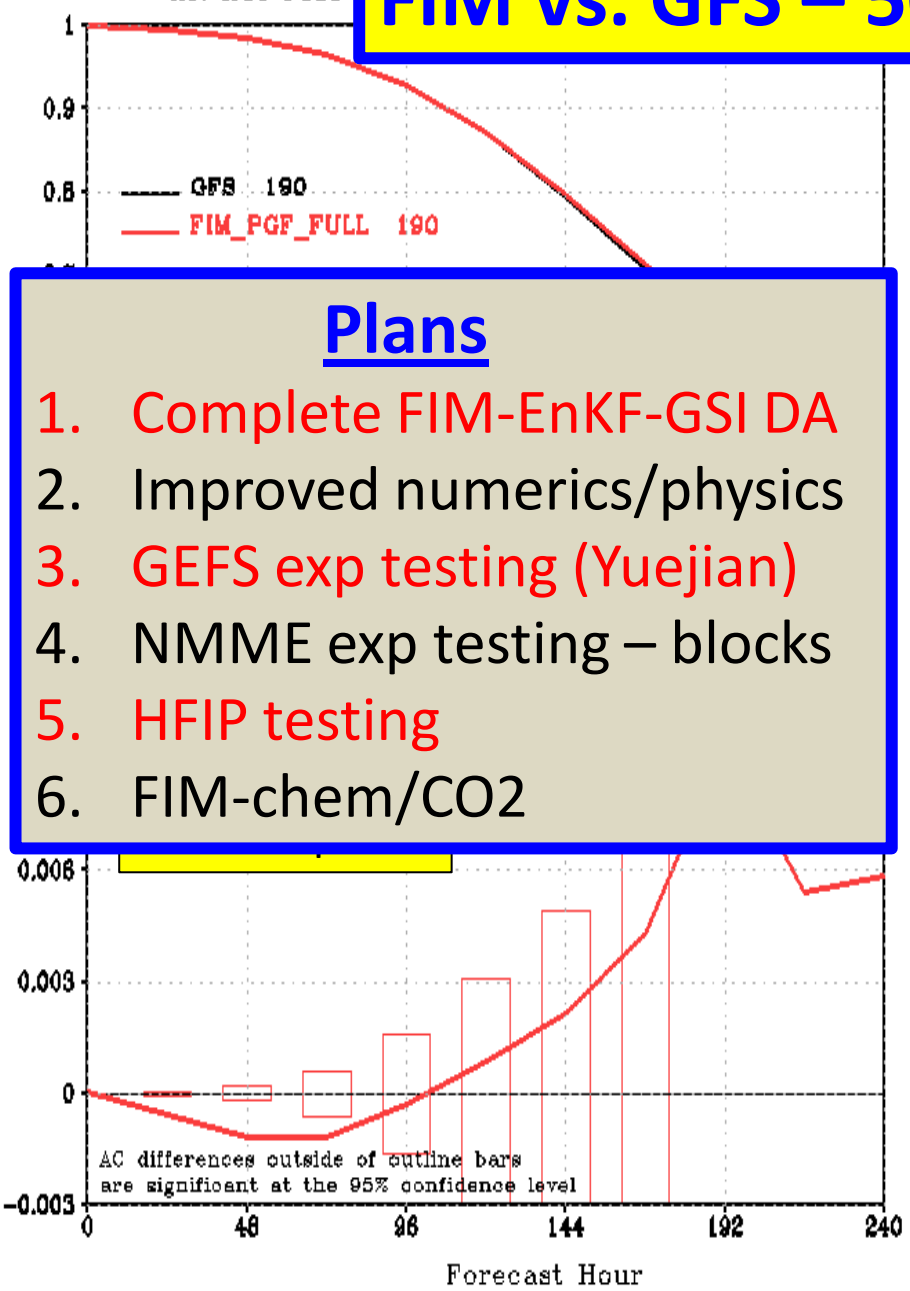
iHYCOM – Icosahedral Hybrid Coordinate Ocean Model

- Matched grid design to FIM for coupled ocean-atmosphere prediction system
- Experimental testing at ESRL, Navy development
- Testing of coupled FIM/iHYCOM – toward experimental NMME contribution



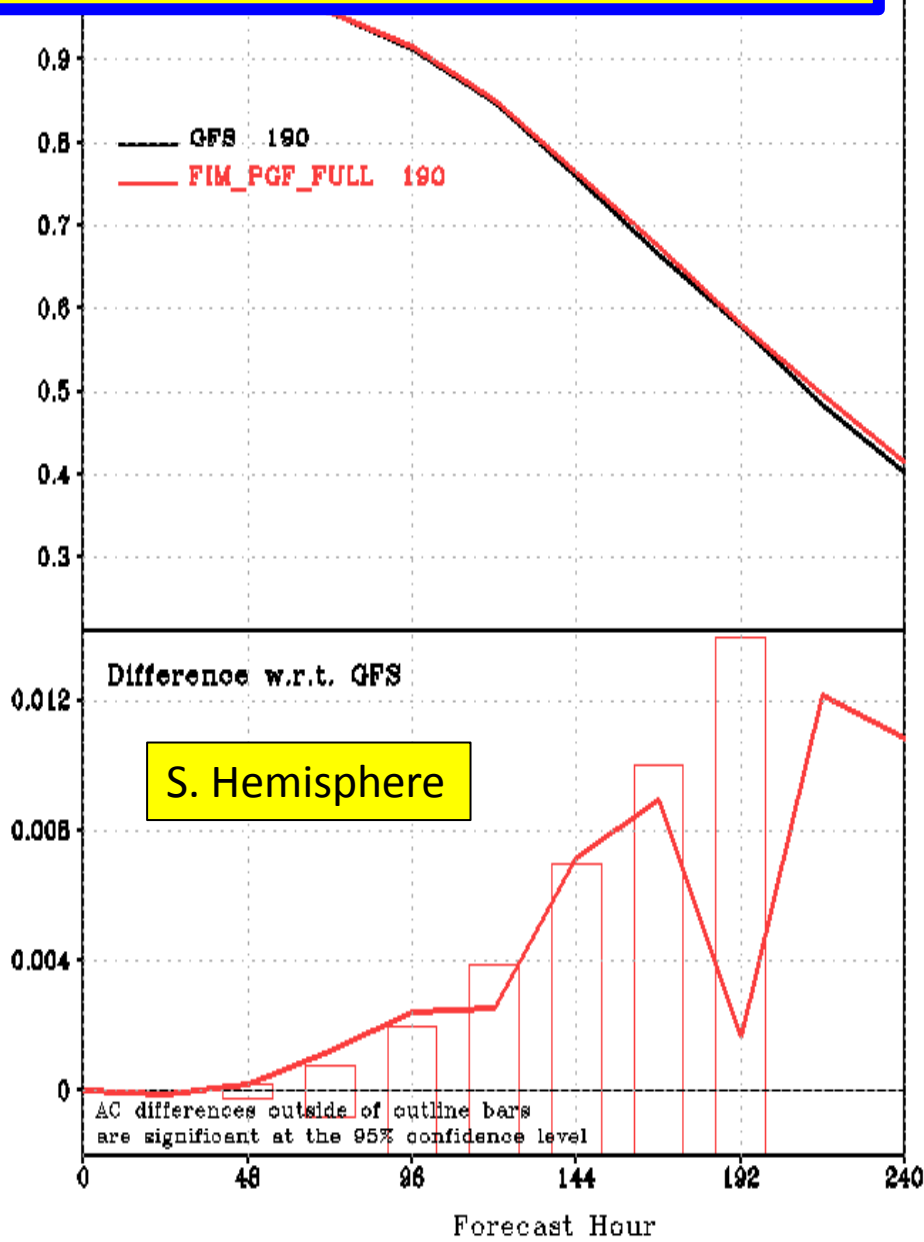

WIND: RMSE
20111225–20121203 Mean, G2/TRO 00Z
GFSY
FIMY–GFSY
FIM vs. GFS using ECMWF as verification - Tropical winds
http://www.emc.ncep.noaa.gov/gmb/wx24fy/fimy/
Forecast Hour

FIM vs. GFS – 500 hPa AC - Jan-July 2012



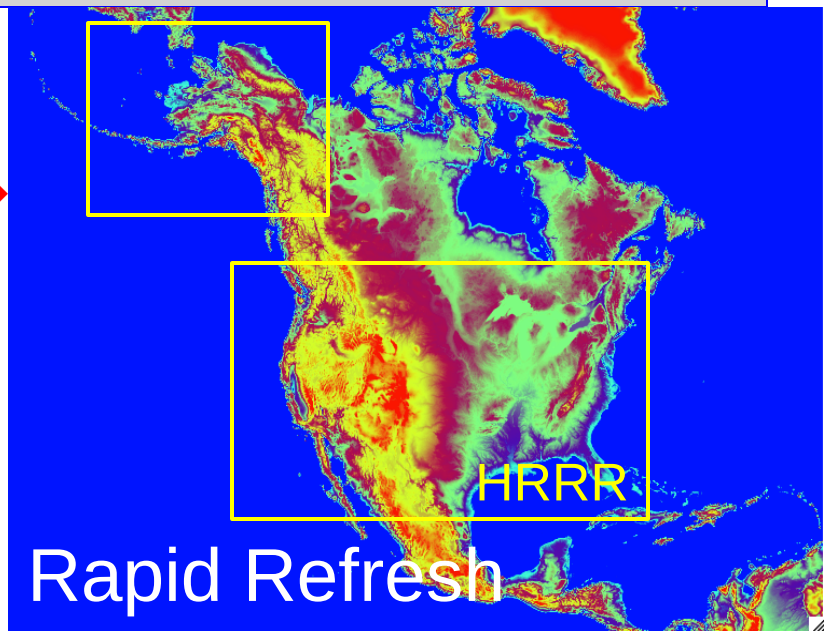
Plans

1. Complete FIM-EnKF-GSI DA
2. Improved numerics/physics
3. GEFS exp testing (Yuejian)
4. NMME exp testing – blocks
5. HFIP testing
6. FIM-chem/CO2



Evolution of hourly updated NOAA modeling

- May 2012 – Rapid Refresh operational at NCEP
- June 2013 – Rapid Refresh v2 –
  - PBL/soil/radar assimilation enhancements → improved sfc forecasts, lower moist bias
  - hybrid assimilation
  - model – MODIS, cloud/PBL/numerical improvements, updated WRF
- 2013-15 – HRRR @ESRL improves, add Fairmont HRRR to reach 99%
  - 3km/15min radar assimilation
- 2015? – High-Resolution Rapid Refresh operational at NCEP for CONUS



N. American Rapid Refresh Ensemble

- **NEMS-based NMM, ARW cores**
- **Hourly updating with GSI-hybrid EnKF**
- **Initially 6 members, 3 each core, physics diversity (RAP, NAM, NCAR suites)**
- **Forecasts to 24-h**
- **NMM to 84-h 4x per day**

- Later 2015 – Ensemble Rapid Refresh – **NARRE** w/ hybrid assimilation
- 2016 – Add operational Alaska HRRR
- 2018? – CONUS Ensemble HRRR – **HRRRE**