WRF in NCEP Operations

Geoff DiMego, Zavisa Janjic, Tom Black, Eric Rogers, Matt Pyle, Jun Du,
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22 June 2010

N C E P

Where the Nation's climate and weather services begin

T O P I C S

- Condensed Chronologies
- Unsolicited Endorsements
- HiResWindow & Radar Use in GSI
- Short Range Ensemble Forecast (SREF)
- North American Mesoscale (NAM)
- Future Plans: NMMB & NEMS

NMM, ARW in NCEP Operations

- **Pre-WRF NMM at NCEP**
- May 2000: nonhydrostatic option released in upgrade to NCEP's workstation Eta
- May 2001: NMM model equations, solution techniques & test results published in Janjic, Gerrity, and Nickovic, 2001, Mon. Wea. Rev. also Janjic, 2003, Meteor. & Atmos. Phys.
- February 2002: HiResWindow runs upgraded to use 8 km NMM replaces 10 km Eta (hydrostatic)
- February 2002: On-Call Emergency Response (OCER) capability begins using 4 km NMM to support HYSPLIT
- May 2003: Fire Weather / IMET Support runs implemented using 8 km NMM

- **WRF-ARW at NCEP**
- September 2004: HiResWindow first WRF implementation of 10 km WRF-ARW v1.3
- June 2005: HiResWindow upgraded to use 5.8 km WRF-ARW with explicit convection
- December 2005: Short Range Ensemble Forecasting system adds 3 members using 45 km WRF-ARW v2.0
- September 2007: HiResWindow expanded domain and upgraded to 5.1 km WRF-ARW v2.2.1
- **October 2009: SREF WRF-ARW upgraded to v2.2.1, add 2 members and increase resolution to 35 km**

WRF-NMM in NCEP Operations

- April 2004 thru present: NSSL/SPC Spring Program, daily developmental run of 4.5 km WRF-NMM with explicit convection
- September 2004: HiResWindow first WRF implementation of 8 km WRF-NMM v1.3 replaces pre-WRF NMM
- June 2005: HiResWindow upgraded to use 5.1 km WRF-NMM with explicit convection
- December 2005: Short Range Ensemble Forecasting system adds 3 members using 40 km WRF-NMM v2.0
- June 2006: NAM runs use 12 km WRF-NMM v2.1 & WRF-GSI replacing Eta & Eta-3DVar
- September 2007: HiResWindow expanded domain and upgraded to 4 km WRF-NMM v2.2.1
- December 2008: final major NAM/NMM upgrade

Recommended Talks + Tutorial

- **Session 2: WRF Model Development and Operations**
  - **2.2** NCEP Operational Hurricane WRF (HWRF) Modeling System. **Vijay Tallapragada (**NCEP/EMC), Qingfu Liu, Young Kwon, Zhan Zhang, Robert Tuleya, Janna O'Connor, Samuel Trahan, Naomi Surgi, Bill Lapenta, and Stephen J. Lord
- **Session 4: Physics Development and Testing**
  - **4.8** Test Results of Hurricane Related Inland Streamflow Forecasts**. Yihua Wu** (NCEP), and Michael Ek

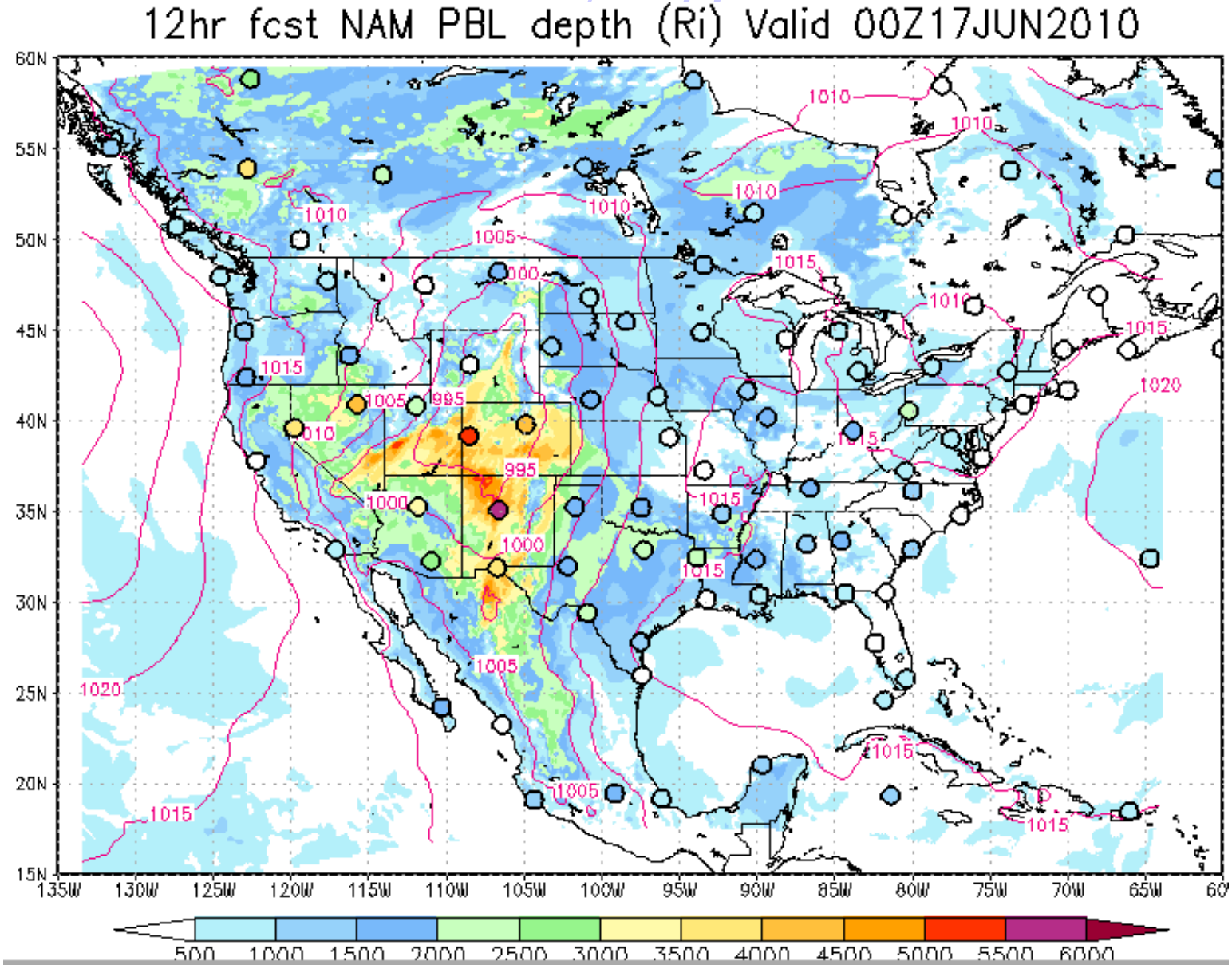
❑ GSI Community Tutorial June 28-30, 2010

Recommended POSTERS

2:30 P.M. – 5:30 P.M, Wednesday, June 23

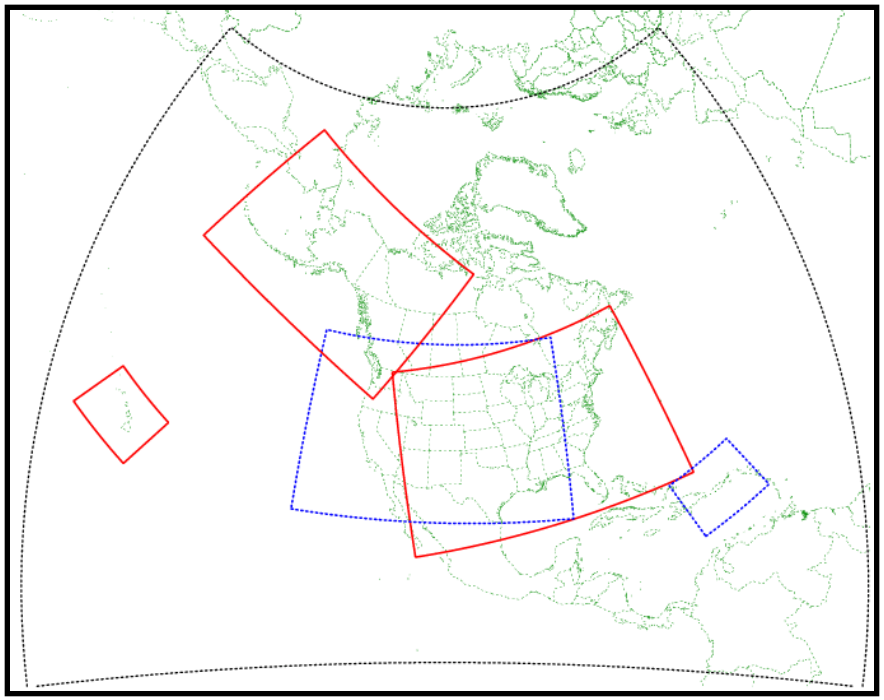
- **WRF Model Development**
  - **P.1** Development and application of the Unified Post Processor for WRF NMM, WRF ARW, and GFS. **Hui-Ya Chuang** (NCEP)
    - Future updates will include Ri-based PBL height (to be compatible with NCEP's verification & analysis projects which are based on diagnosing PBL height from radiosonde, aircraft & Profiler soundings using critical Ri (=0.25) [see next slide]
- **Physics Development and Testing**
  - **P.44** Some Cold Region Physics Issues in WRF. **Yihua Wu** (NOAA/NCEP/EMC), and Michael Ek
  - **P.45** Impacts of the new Satellite Derived Land Products for WRF. **Vince Wong** (NCEP/EMC), and Michael Ek

NAM 12 hr Forecast Ri-Based PBL Height with Verifying RAOBs



HiResWindow Fixed-Domain Nested Runs
Configuration/Schedule as of September 2007

- 4-5 km explicit runs of both NMM & ARW at same time every day - ***if & only if*** **no** hurricane runs are needed
- 00Z : ECentral & Hawaii
- 06Z : WCentral & Puerto Rico
- 12Z : ECentral & Hawaii
- 18Z : Alaska & Puerto Rico



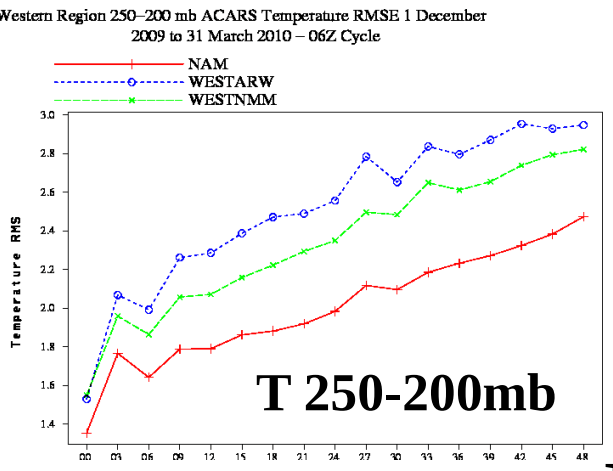
- **Daily displays of both ARW + NMM are at:**

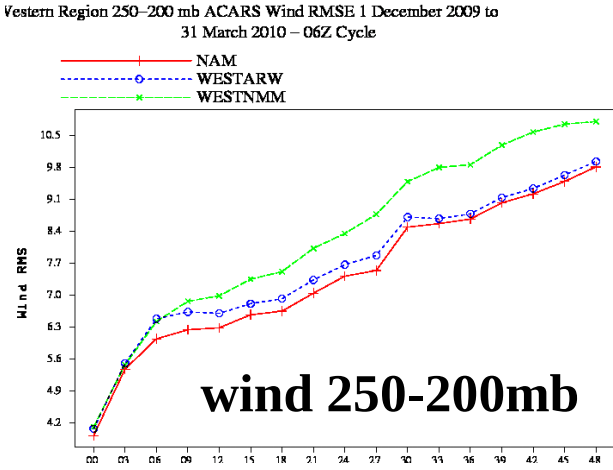
  http://www.nco.ncep.noaa.gov/pmb/nwprod/analysis/ **(see next slide for example) and**

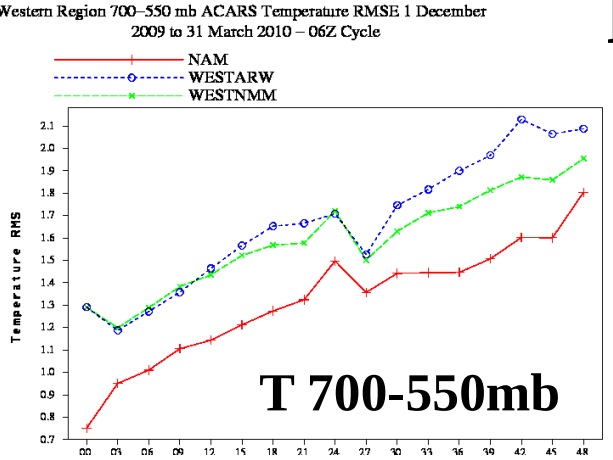
  http://www.emc.ncep.noaa.gov/mmb/mmbpll/nestpage/

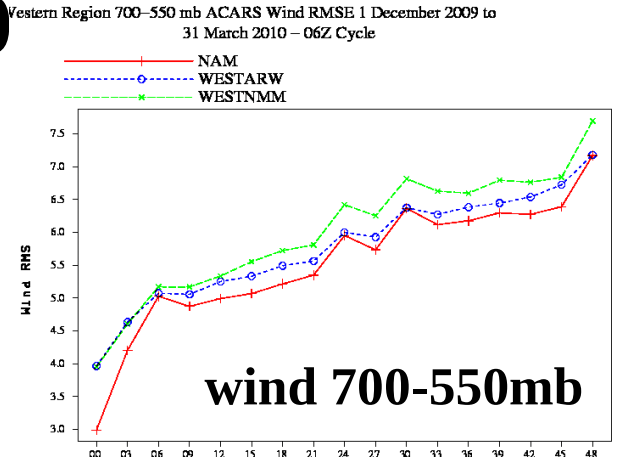
- **Promised to 'appear' on AWIPS-Satellite Broadcast Network and NOAAport**

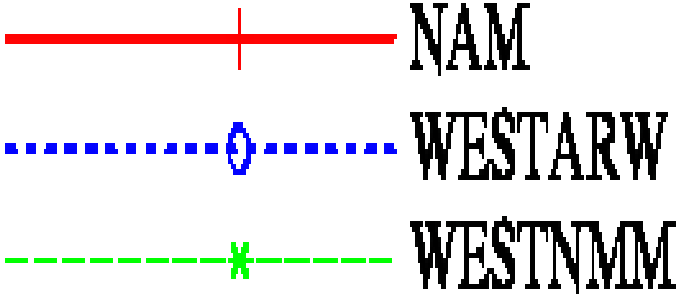
HiResWindow Western Nest Verification Stats RMS vs ACARS Dec 2009-Mar 2010

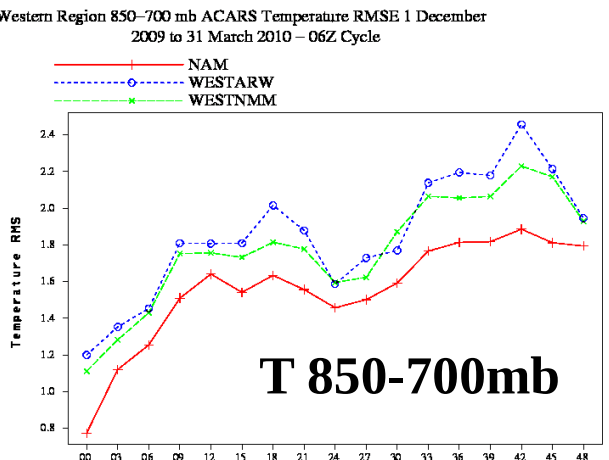


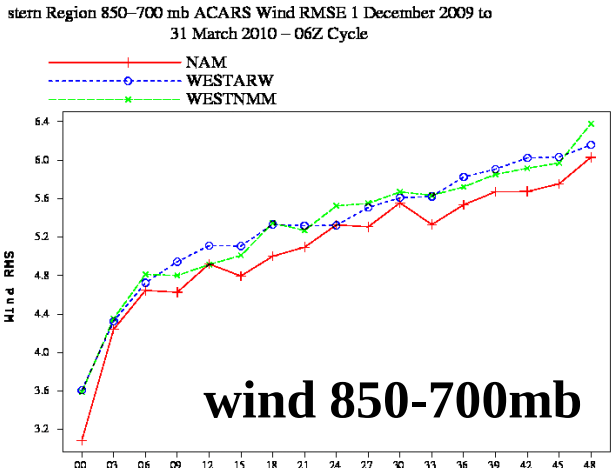






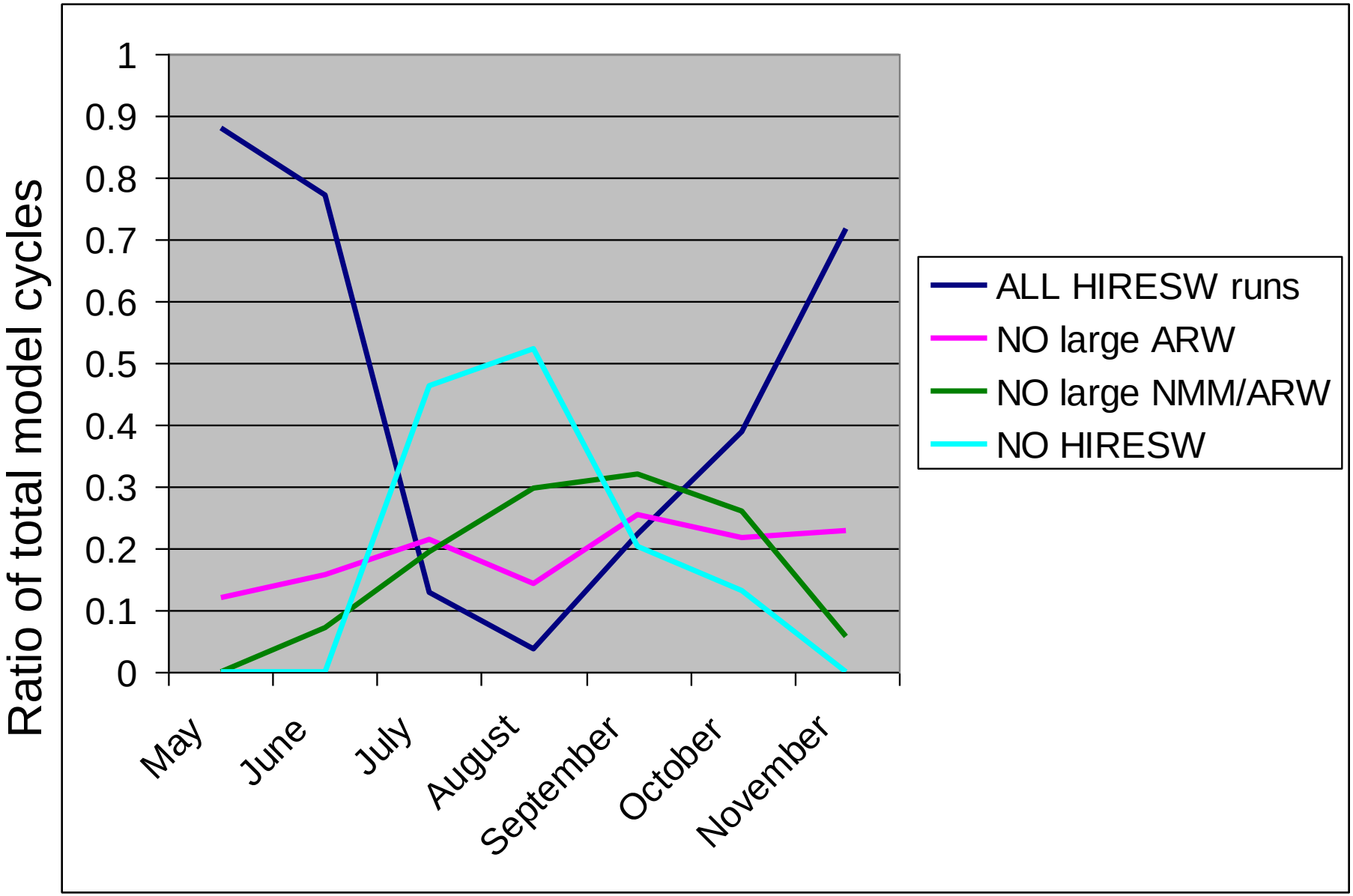






Frequency of HiResWindow Runs

Typically, no runs at all 50% of time in July & August



Model Analyses & Forecast Page

ARW Simulated Radar Reflectivity

Model Analyses and Forecasts
HIRESW ARW 12 UTC

	00 UTC	06 UTC	12 UTC	18 UTC
NAM	coarse medium fine 3-hr Precip Charts 4-panel charts 19-Jun-10	coarse medium fine 3-hr Precip Charts 4-panel charts 19-Jun-10	coarse medium fine 3-hr Precip Charts 4-panel charts 19-Jun-10	coarse medium fine 3-hr Precip Charts 4-panel charts 18-Jun-10
GFS	coarse medium fine 3-hr Precip Charts 4-panel charts 19-Jun-10	coarse medium fine 3-hr Precip Charts 4-panel charts 19-Jun-10	coarse medium fine 3-hr Precip Charts 4-panel charts 19-Jun-10	coarse medium fine 3-hr Precip Charts 4-panel charts 18-Jun-10
GEFS	Spaghetti Charts Means & Spreads 19-Jun-10	Spaghetti Charts Means & Spreads 19-Jun-10	Spaghetti Charts Means & Spreads	Spaghetti Charts Means & Spreads 18-Jun-10
HRW	Eastern US NMM ARW 19-Jun-10	Western US NMM ARW 19-Jun-10	Eastern US NMM ARW 18-Jun-10	Alaska NMM ARW
	Hurricane Graphics			
GHM	Full Domain 19-Jun-10		Nested Domain 19-Jun-10	
HWRF	Full Domain 19-Jun-10		Nested Domain 19-Jun-10	
	03 UTC	09 UTC	15 UTC	21 UTC
SREF	Charts 19-Jun-10	Charts 19-Jun-10	Charts 18-Jun-10	Charts 18-Jun-10

Ht	300mb Wind, Ht	500mb Vort, Ht	700mb RH, Ht	850mb Temp, Ht	Tot Pcpn 03 hrs	Tot Pcpn 12 hrs	Tot Pcpn 24 hrs	Tot Pcpn 36 hrs	Tot Pcpn 48 hrs	Sim Reflectivity	MSLP 1000 - 500mb
	Loop	Loop	Loop	Loop	Loop	Loop	Loop	Loop	Loop	Loop	Loop
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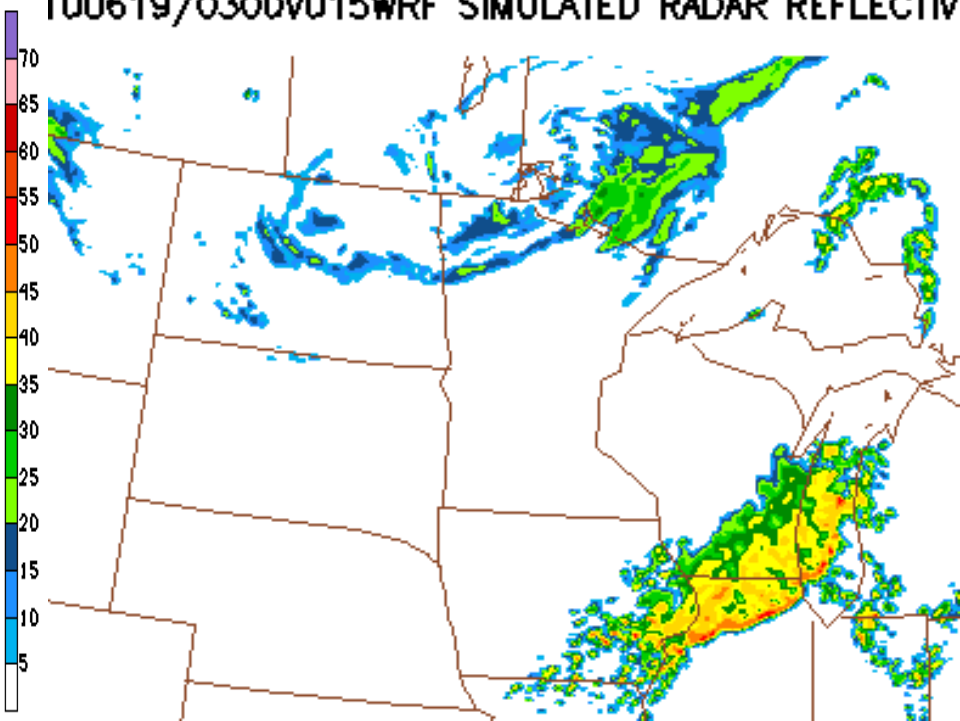
	039	039	039	039	039	039	039	039	039	039	039
	042	042	042	042	042	042	042	042	042	042	042
	045	045	045	045	045	045	045	045	045	045	045

100619/0300V015WRF SIMULATED RADAR REFLECTIV



Model Analyses & Forecast Page

NMM Simulated Radar Reflectivity

Model Analyses and Forecasts
HIRESW NMM 12 UTC

	00 UTC	06 UTC	12 UTC	18 UTC
NAM	coarse medium fine 3-hr Precip Charts 4-panel charts 19-Jun-10	coarse medium fine 3-hr Precip Charts 4-panel charts 19-Jun-10	coarse medium fine 3-hr Precip Charts 4-panel charts 19-Jun-10	coarse medium fine 3-hr Precip Charts 4-panel charts 18-Jun-10
GFS	coarse medium fine 3-hr Precip Charts 4-panel charts 19-Jun-10	coarse medium fine 3-hr Precip Charts 4-panel charts 19-Jun-10	coarse medium fine 3-hr Precip Charts 4-panel charts 19-Jun-10	coarse medium fine 3-hr Precip Charts 4-panel charts 18-Jun-10
GEFS	Spaghetti Charts Means & Spreads 19-Jun-10	Spaghetti Charts Means & Spreads 19-Jun-10	Spaghetti Charts Means & Spreads	Spaghetti Charts Means & Spread 18-Jun-10
HRW	Eastern US NMM ARW 19-Jun-10	Western US NMM ARW 19-Jun-10	Eastern US NMM ARW 18-Jun-10	Alaska NMM ARW 18-Jun-10
	Hurricane Graphics			
GHM	Full Domain 19-Jun-10		Nested Domain 19-Jun-10	
HWRF	Full Domain 19-Jun-10		Nested Domain 19-Jun-10	
	03 UTC	09 UTC	15 UTC	21 UTC
SREF	Charts 19-Jun-10	Charts 19-Jun-10	Charts 18-Jun-10	Charts 18-Jun-10

500mb Vort, Ht	700mb RH, Ht	850mb Temp, Ht	Tot Pcpn 03 hrs	Tot Pcpn 12 hrs	Tot Pcpn 24 hrs	Tot Pcpn 36 hrs	Tot Pcpn 48 hrs	Sim Radar Reflectivity	MSLP 1000 - 500mb
Loop	Loop	Loop	Loop	Loop	Loop	Loop	Loop	Loop	Loop
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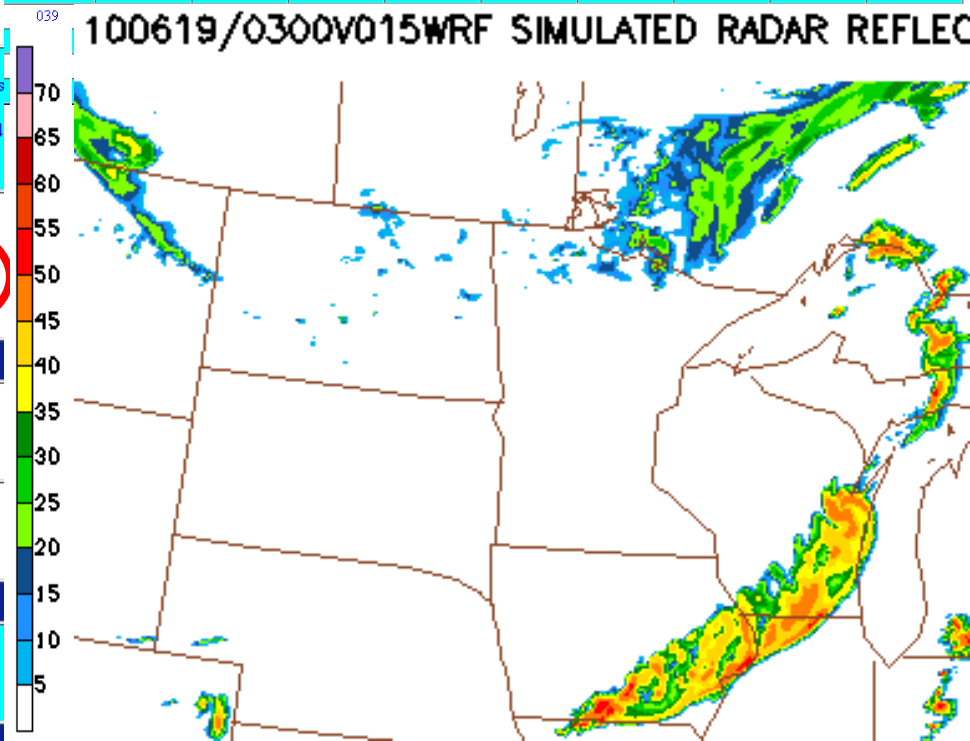

Model Analyses & Forecast Page

NMM Sim. Radar Reflectivity w/Zoom

Model Analyses and Forecasts
HIRESW NMM 12 UTC

	00 UTC	06 UTC	12 UTC	18 UTC
NAM	coarse medium fine 3-hr Precip Charts 4-panel charts 19-Jun-10	coarse medium fine 3-hr Precip Charts 4-panel charts 19-Jun-10	coarse medium fine 3-hr Precip Charts 4-panel charts 19-Jun-10	coarse medium fine 3-hr Precip Charts 4-panel charts 18-Jun-10
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HRW	Eastern US NMM ARW 19-Jun-10	Western US NMM ARW 19-Jun-10	Eastern US NMM ARW 18-Jun-10	Alaska NMM ARW 18-Jun-10
	Hurricane Graphics			
GHM	Full Domain 19-Jun-10		Nested Domain 19-Jun-10	
HWRF	Full Domain 19-Jun-10		Nested Domain 19-Jun-10	
	03 UTC	09 UTC	15 UTC	21 UTC
SREF	Charts 19-Jun-10	Charts 19-Jun-10	Charts 18-Jun-10	Charts 18-Jun-10

500mb Vort, Ht	700mb RH, Ht	850mb Temp, Ht	Tot Pcpn 03 hrs	Tot Pcpn 12 hrs	Tot Pcpn 24 hrs	Tot Pcpn 36 hrs	Tot Pcpn 48 hrs	Sim. Radar Reflectivity	MSLP 1000 - 500mb
Loop	Loop	Loop	Loop	Loop	Loop	Loop	Loop	Loop	Loop
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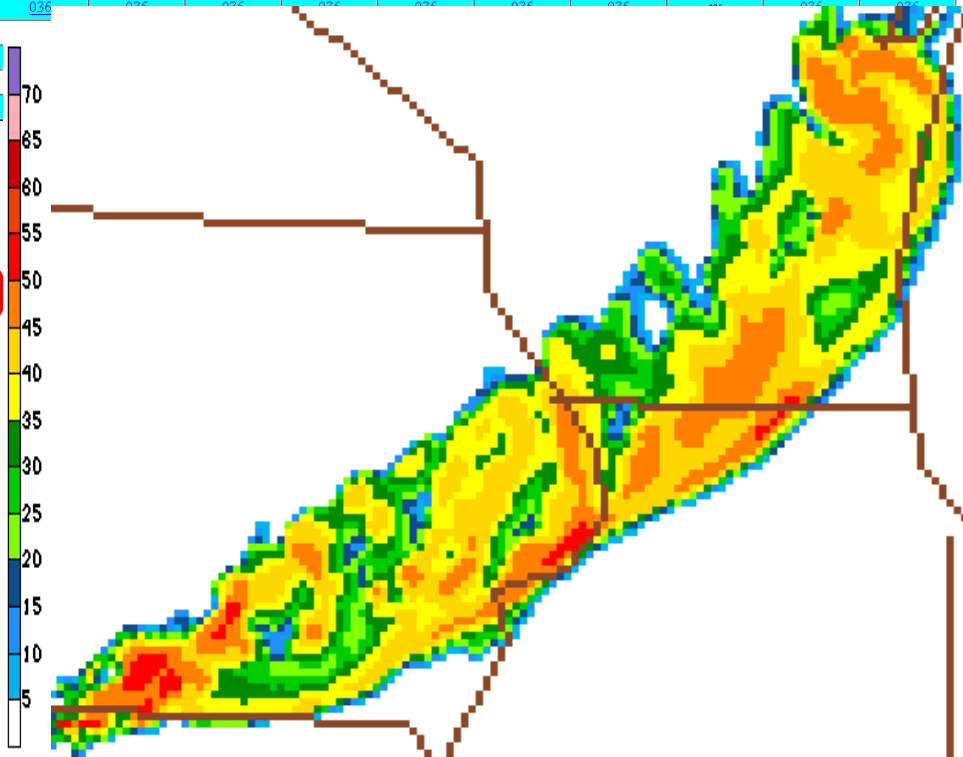
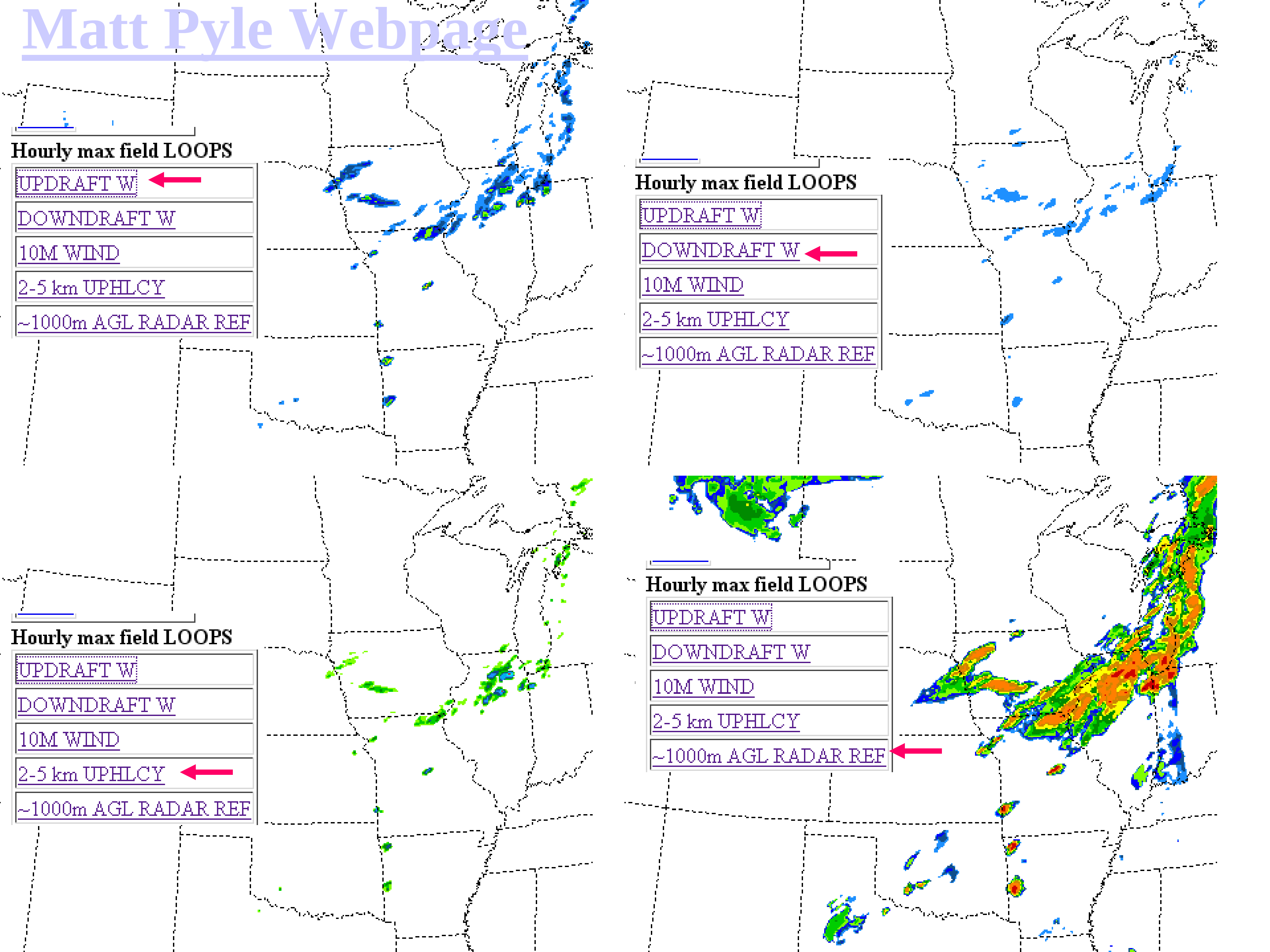


Matt Pyle Webpage



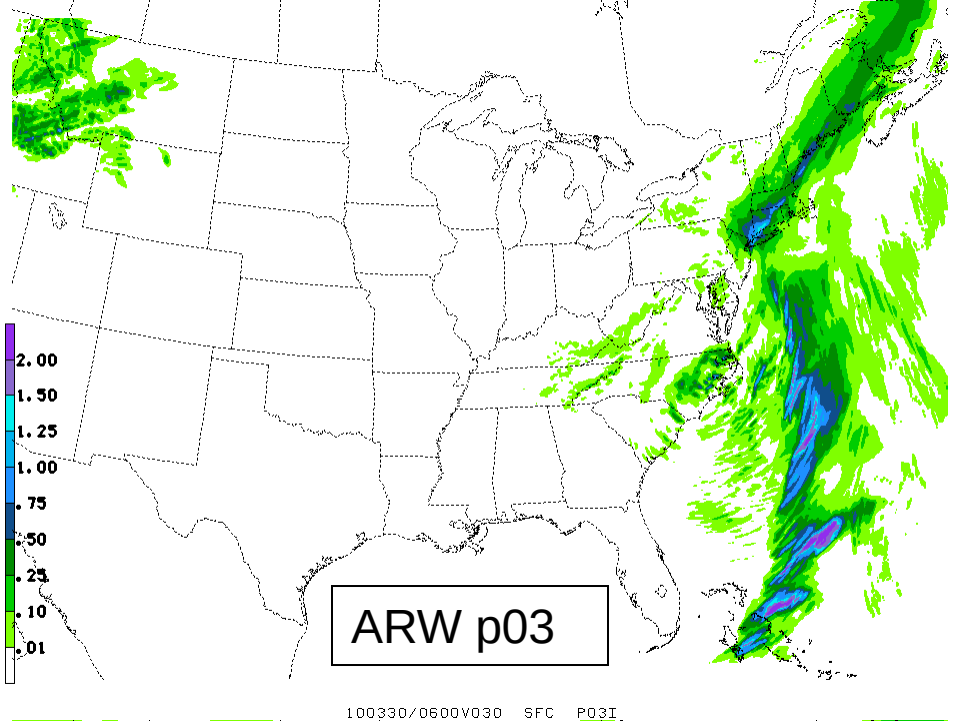
HiResWindow 2010 Upgrade

- Upgrades WRF-NMM from v2.2 to v3.2 and switch to use new, more conservative Eulerian advection for passive quantities (moisture, cloud, condensate and TKE).
- Upgrades WRF-ARW from v2.2 to v3.2 and switch to use positive definite advection for passive quantities (moisture, cloud and hydrometeors).
- Adds hybrid ensemble (Du 2004) products generated by applying SREF 'anomalies' to HiRes base fields to produce a 44 member ensemble from which probabilities can be computed (e.g. Prob. Of Exceedance for critical QPF amounts for Washington's Hanson Dam)
- Adds twice daily runs for Guam (these replace legacy RSM runs for Hawaii)
- Adds generation of BUFR output (hourly point forecasts) from both cores.
- Implementation is currently delayed due into FY2011.

HiResWindow WRF v3.2 Configurations

(No Parameterized Convection)

Dynamic Core	WRF-NMM	WRF-ARW
Horizontal Spacing	4.0 km	5.1 km
Vertical Domain	35 levels 50 mb top Sigma-Pressure	35 levels 50 mb top Sigma
PBL/Turbulence	MYJ	YSU
Microphysics	Ferrier	WSM3
Land-Surface	NOAH	NOAH
Radiation (Shortwave/Longwave)	GFDL/GFDL Lacis-Hansen/Fels-Schwartzkopf	Dudhia/RRTM
Advection of Passive Variables	Conservative Positive Definite	Monotonic Positive Definite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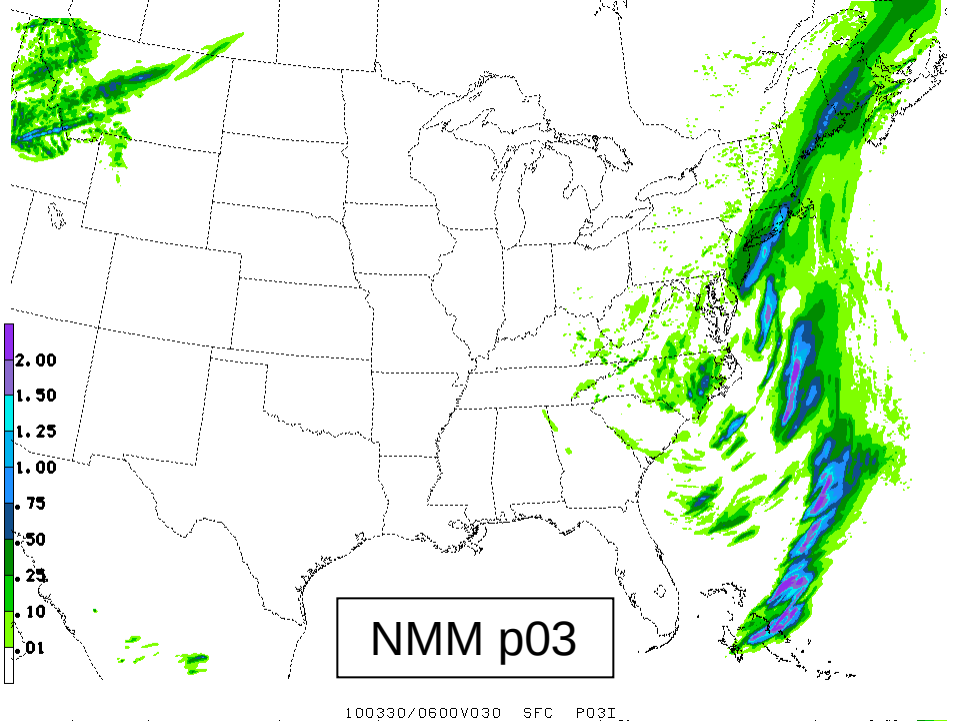
ARW p03
100330/0600V030 SFC PO3I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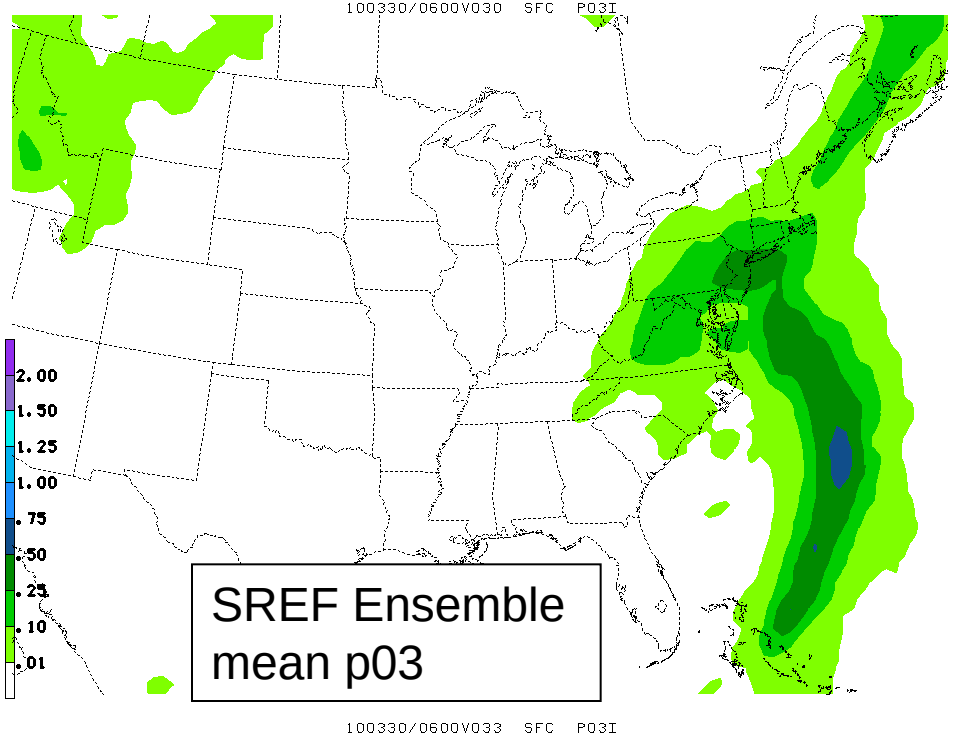
100330/0600V030 SFC PO3I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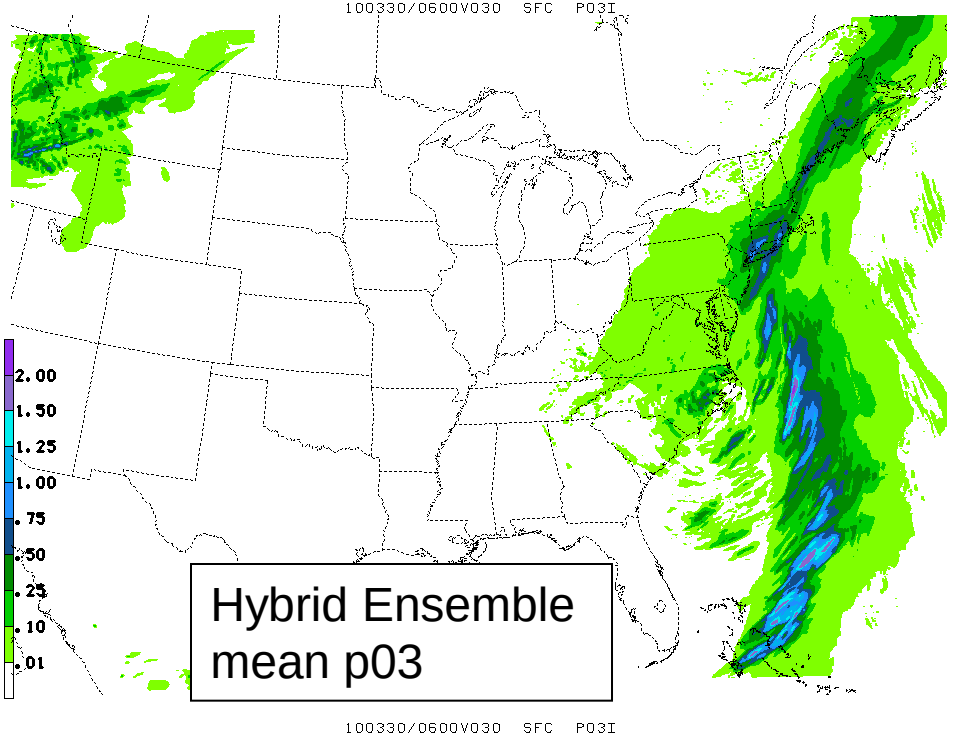
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Hybrid Ensemble mean p03
100330/0600V030 SFC PO3I

HiResWindow 2010 Upgrade Testing & QFP Test Results Summary

- Upgraded code was run for:
  - 40 day period in Dec 2009 - Jan 2010 (cold season)
  - Month of June 2009 (warm season).

- QPF stats show:
  - NMM: small improvement (except at .01”) in cold season testing, but a big improvement in the warm season especially reduced bias (but still to large).
  - ARW: neutral impact for the cold season, and a more significant positive impact at higher thresholds in the warm season.

HiResWindow 2010 Upgrade
Fcst-vs-Obs Test Results Summary

- Upper air stats:
  - NMM shows big improvement in warm season, little impact in cold season.
  - ARW shows big improvement in cold season, smaller improvement in warm season.

- Surface stats:
  - NMM shows improved 2m T, 10 m winds for cold season, West & AK regions.
  - ARW cold season impact more mixed - distinctly warmer 2 m temperatures West & AK.
  - Warm season impacts are more muted, daytime max 2 m T generally improved (warmer) for ARW.

Plans for HiResWindow

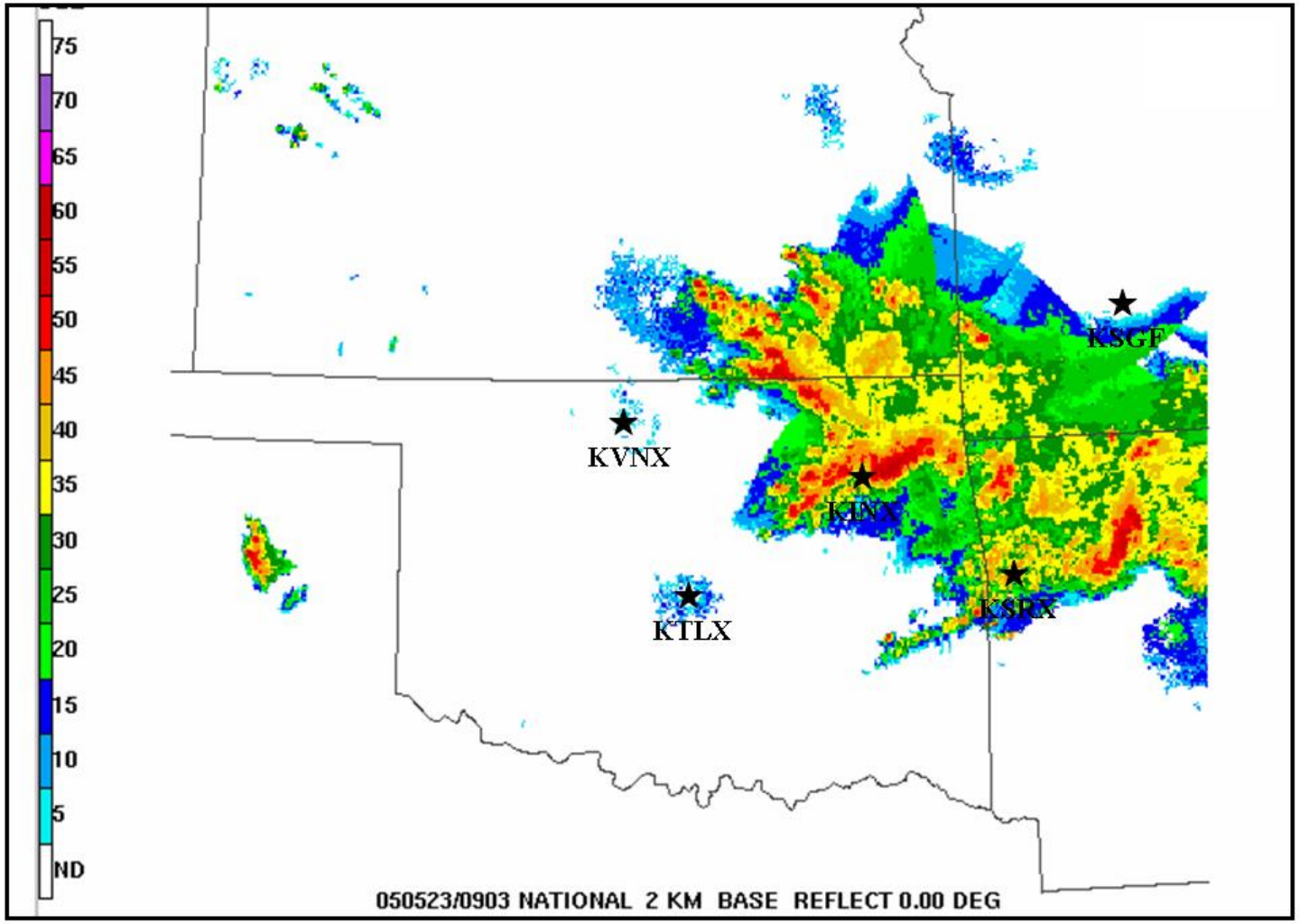
- Improve initial conditions (Shun Liu & Dave Parrish)
  - Re-apply GSI analysis (~another 'outer-loop')
    - Using radial winds only
    - Shorten decorrelation length for background error covariance
  - Apply Diabatic Digital Filter (ala RUC)
    - Force latent heating from 88D reflectivity mosaic
- Improve resolution to ~2-3 km
- Replace NMM with NMMB
- Would follow NAM upgrade

Radar Wind Obs in GSI

- WSR-88D radar wind observations
  - VAD wind profiles
  - Level-2 (full res. - NCEP gets all except 7 in Alaska)
  - Level-2.5 (on-site super-obs – only backup for Level 2)
  - Level-III (NIDS – only backup for Level 2/2.5)
- Radial Wind QC in GSI
  - Increase obs error if model terrain and observation height are too different
  - Increase obs error for observation over high topography
  - Reject Level 2/2.5/3 wind if VAD profile was rejected
  - Gross error check

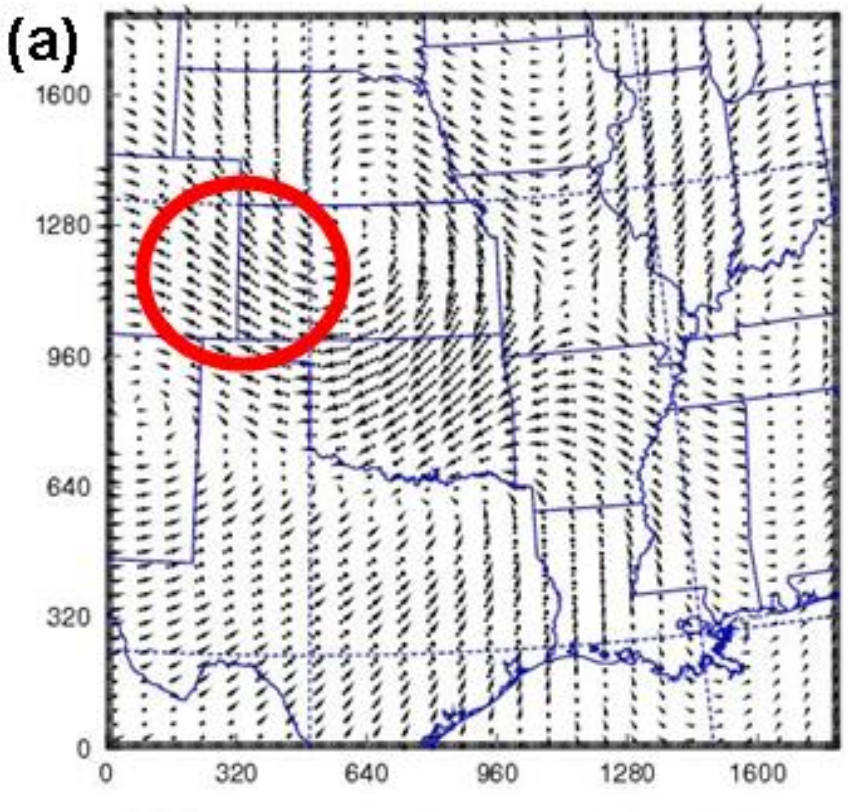
GSI Test Case for Use of Radar Wind

Reflectivity at 0900 UTC on 23 May 2005

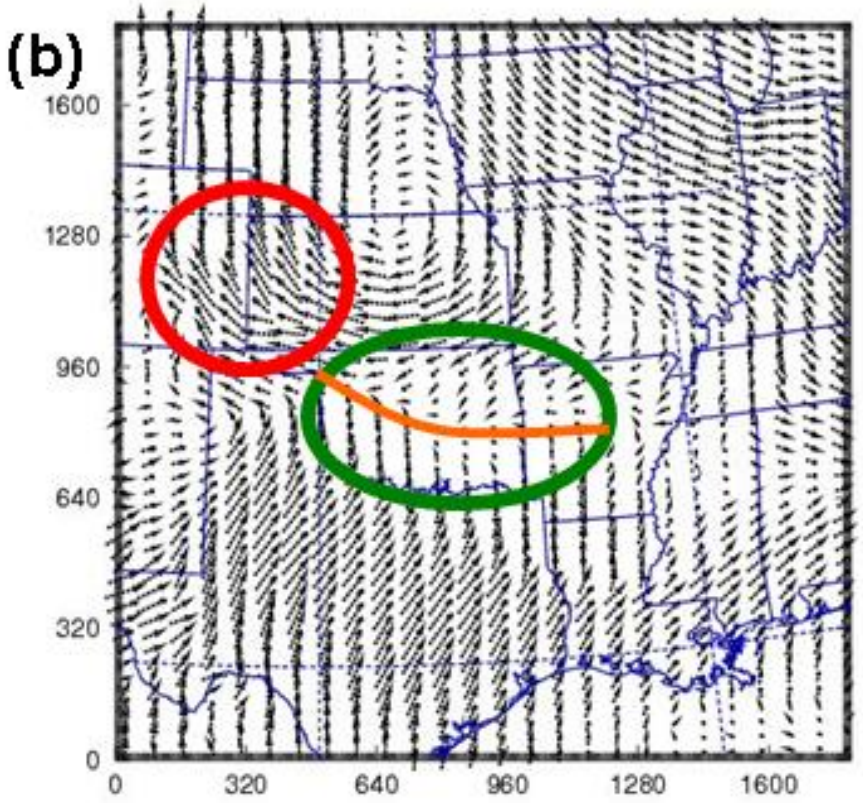


Analysis using default decorrelation length

Increment of the analyzed winds

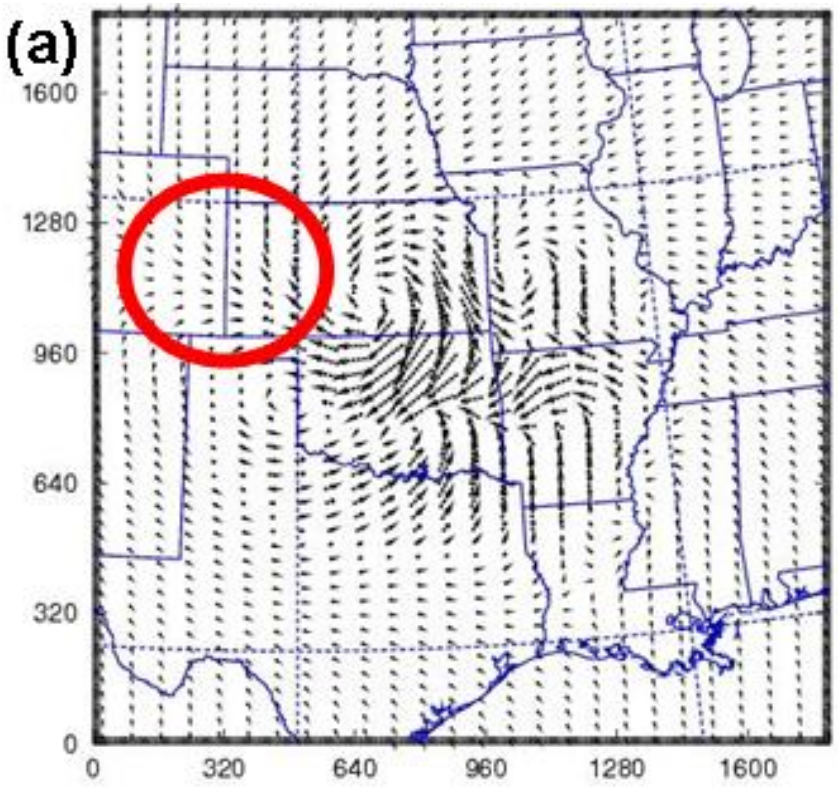


Full wind vectors

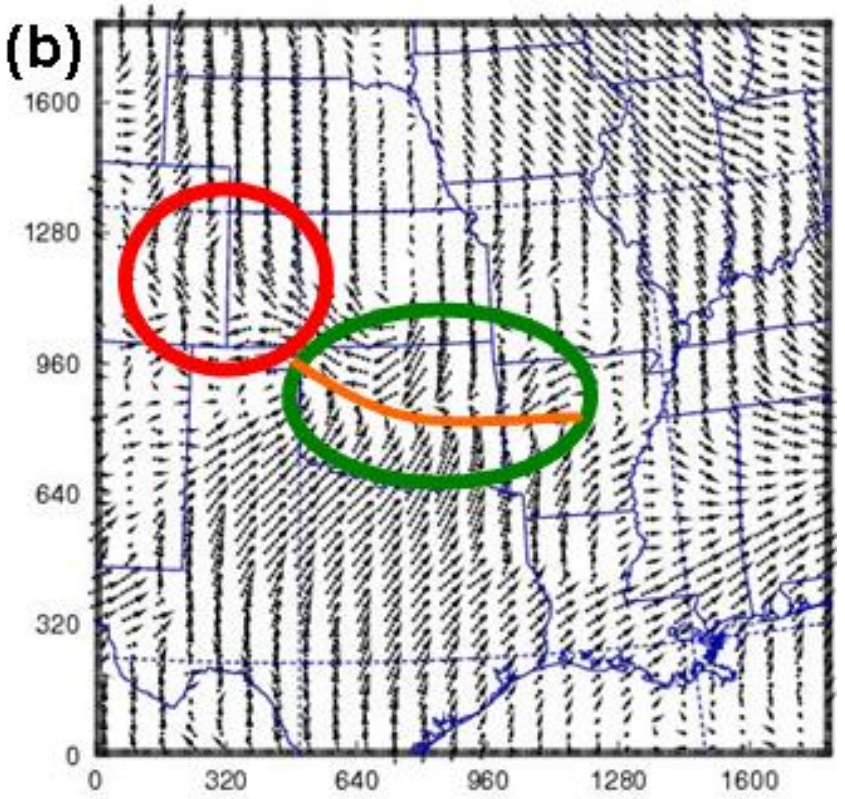


Analysis using <u>one fourth the default</u> decorrelation length

Increment of the analyzed winds

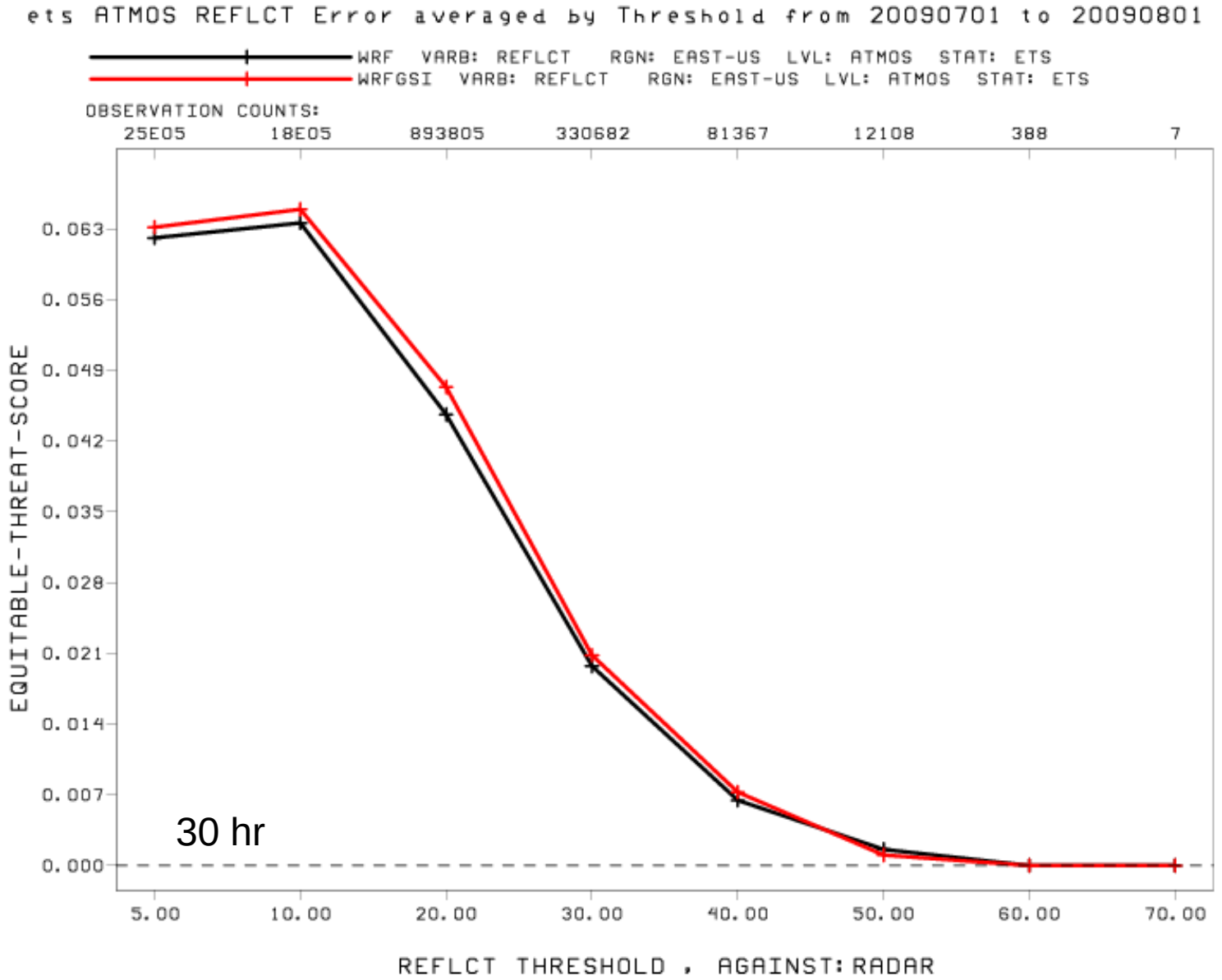


Full wind vectors



Impact of Radial Wind Use

ETS of 30hr Sim.Refl. vs 88D Mosaic



Short Range Ensemble Forecast (SREF) System

- Common bred-mode perturbation generator
- Common ensemble product generator
- Four-per-day runs started July 2006
- Bias Correction added December 2007
- **Major SREF upgrade October 2009**
- Routine displays etc. are available at:
  - http://www.emc.ncep.noaa.gov/mmb/SREF/SREF.html
  - http://www.nco.ncep.noaa.gov/pmb/nwprod/analysis/
- Various Displays of ensemble BUFR soundings
  - http://www.emc.ncep.noaa.gov/mmb/srefmeteograms/sref.html

SREF October 2009 Upgrade: Science

- Version upgrades for NMM, ARW and RSM
  - WRF version upgraded from 1.3 to 2.2
- Resolution increases for NMM from 40km to 32km, for ARW from 45km to 35km, for RSM from 42km to 32km
- Increase WRF membership from 6 to 10 (5 NMM + 5 ARW) by reducing Eta membership from 10 to 6
- Use global perturbations based on Ensemble Transform method for all ten WRF members instead of regional breeding
- More physics diversity in RSM: replace Zhao cloud scheme with Ferrier scheme for 3 SAS members

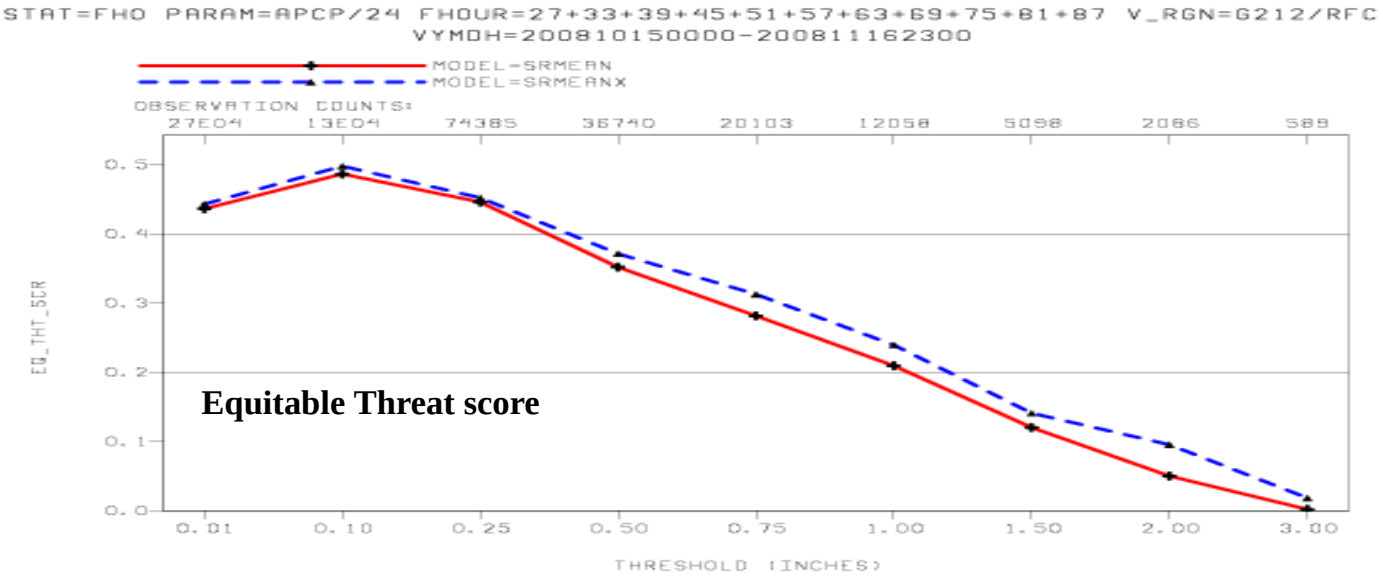
SREF October 2009 Upgrade: Products

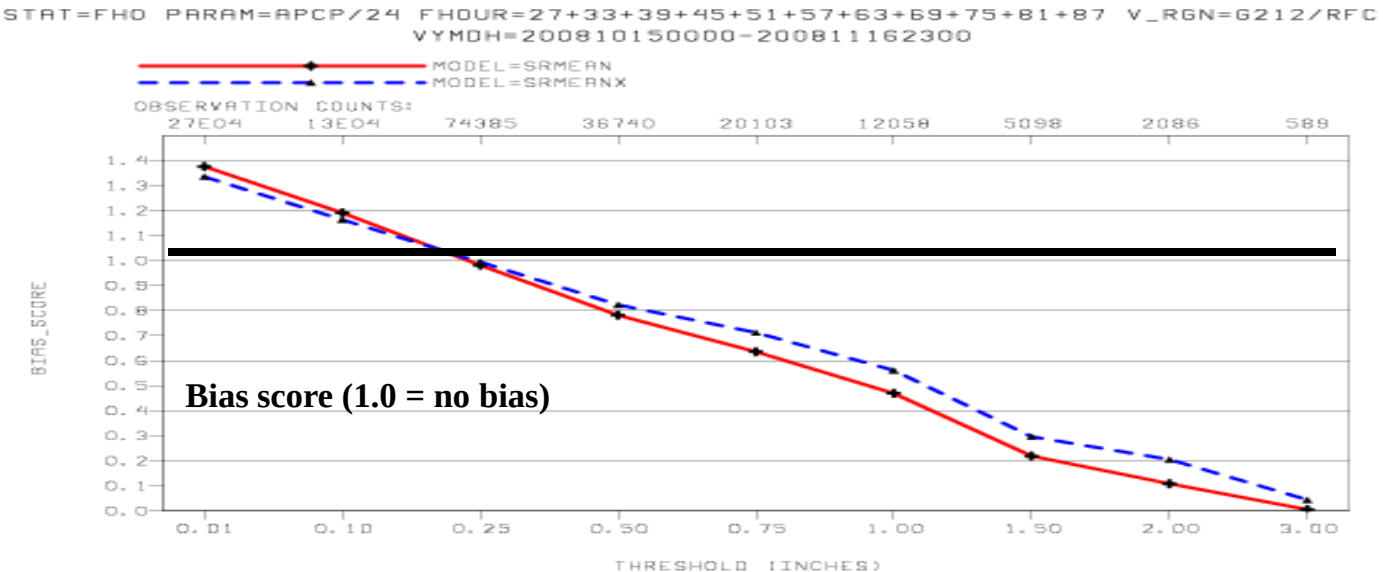
- Output frequency was increased from 3-hrly to 1-hrly for the 1st 39 hr (pgrb) and all the way to 87 hr (bufr sounding) (for SPC and AWC)
- Added composite radar reflectivity, radar echo top, Richardson-Number-based PBL height
- Added aviation (for AWC) and wind-variance fields (for DTRA) to ensemble products
- Added diagnosis of tropical cyclone tracks
- Processed the "big-binary" SREF output file into individual BUFR station time-series

WRF v2.2 Members (5 each) after October 2009 Upgrade

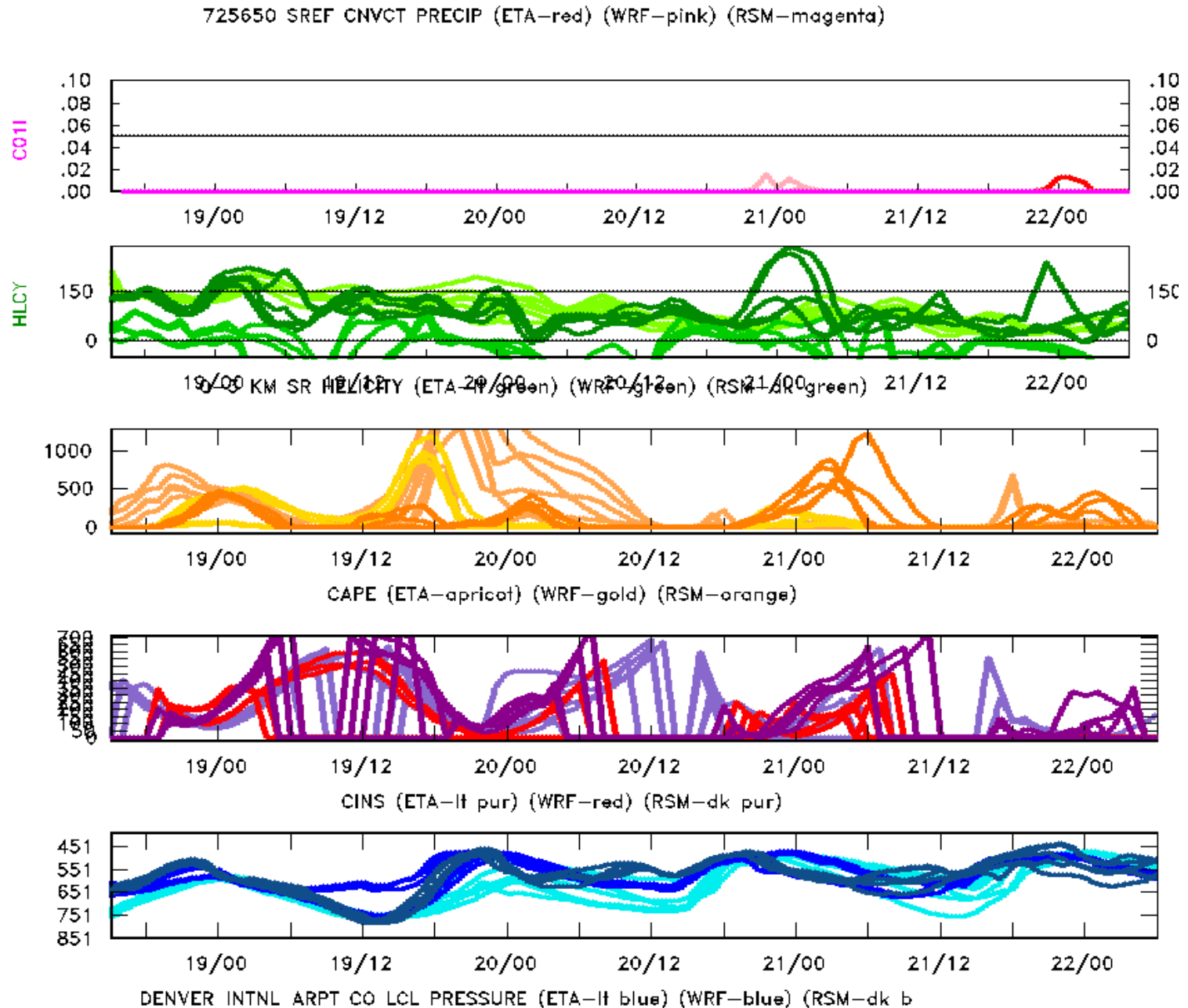
	WRF-NMM	WRF-ARW
Horizontal Grid	32 km	35 km
Vertical Domain	52 levels 50 mb top Sigma-Pressure	36 levels 50 mb top Sigma
Convection	BMJ	KF
PBL/Turbulence/Surface Layer	MYJ	YSU
Microphysics	Ferrier	WSM3
Land-Surface	NOAH	NOAH
Radiation (SW/LW)	GFDL/GFDL Lacis-Hansen/Fels-Schwartzkopf	Dudhia/RRTM

Equitable Threat score (ETS) and Bias score of 24h-accumulated precipitation forecasts of ensemble mean over CONUS, averaged over the period of Oct. 15 – Nov. 16, 2008. New SREF is in dash line and old SREF in solid line. Both ETS and Bias score improved, smaller bias and larger ETS for all thresholds especially heavier precipitation, for the new SREF (against Stage-II precip analysis)





Convective Meteogram from SREF BUFR



Plans for SREF (2011)

- Drop legacy models: Eta and RSM
- Add NEMS-based NMMB
- Keep ensemble size at 21 member runs:
  - 7 WRF-ARW + 7 WRF-NMM + 7 NEMS-NMMB
- Upgrade WRF members to version 3.3
- Increase horizontal resolution to ~22 km
- Use ET or ETR technique in place of breeding
- Exploit stochastic perturbation techniques in physics
- Integrate “lessons-learned” from HFIP effort, e.g. use of Kernel Density Estimate (KDE) technique

North American Mesoscale (NAM)

- NAM / WRF-NMM Displays etc. are available at:

  http://www.emc.ncep.noaa.gov/mmb/mmbpll/opsnam/

  http://www.nco.ncep.noaa.gov/pmb/nwprod/analysis/

- NAM Implementations (all minor, 1st 3 were in WRF v3.1)
  - 3 Nov 2009 – Minor "bug fix" bundle
    - Fixed horizontal advection of W and height in the non-hydrostatic module; missing factor of 2 added
    - Removed the addition of rain water mixing ratio to the input cloud water mixing ratio array used by the GFDL radiation code making the clouds less opaque to SW and LW radiation at grid points where rain is falling
    - Corrected turbulence routine to declare and define CAPA (R/Cp)
    - Surface (skin) temperature is constrained to be no greater than 350K. This will eliminate spurious values at the NAM lateral boundary (not used in NAM integration, but they did cause two SREF failures in April + May
    - The assumed fraction of large, precipitating ice particles to the total number concentration of ice particles (FLARGE2) is reduced from 0.2 to 0.03, which acts to increase the number of small, nonprecipitating ice particles.

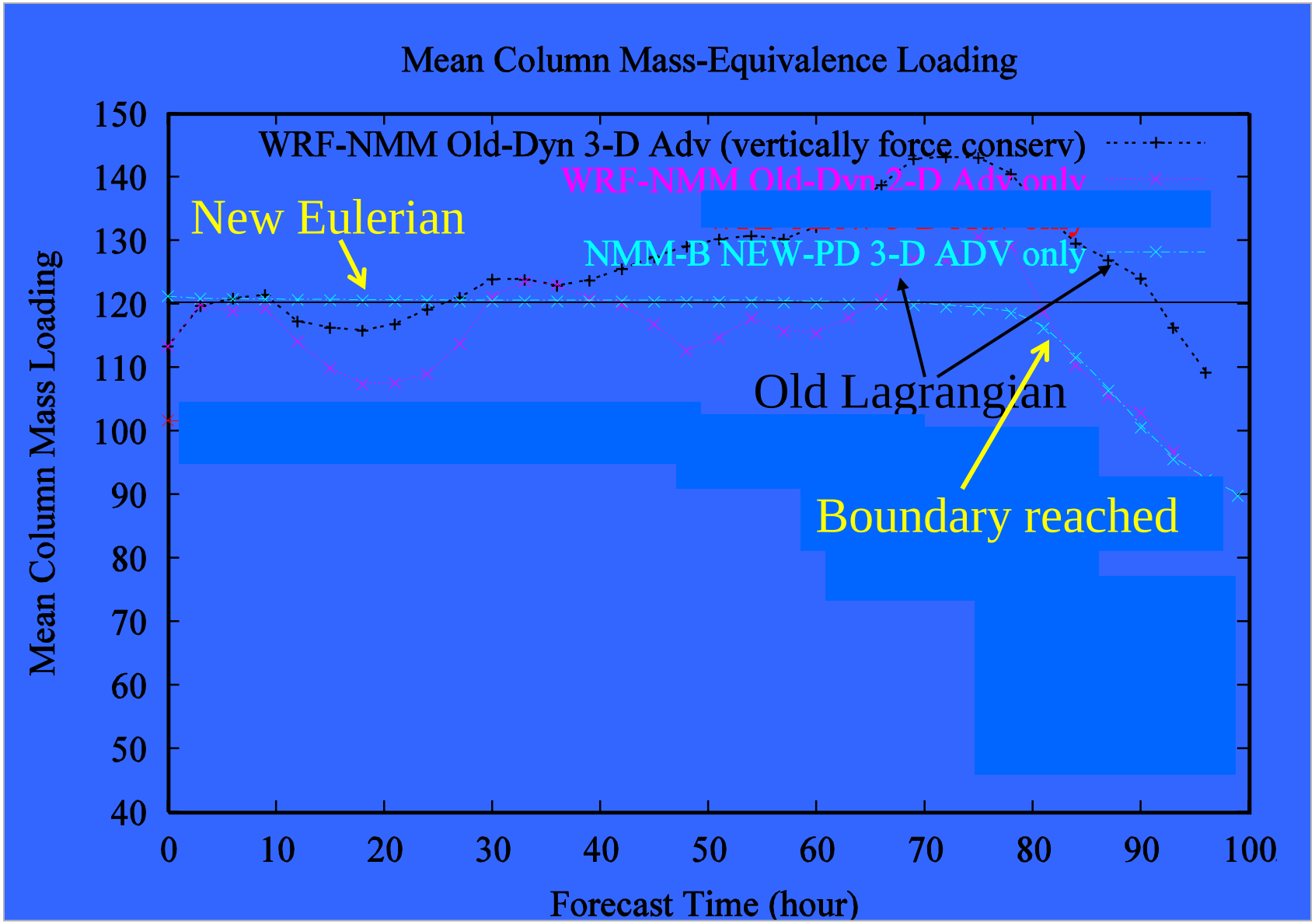
New to WRF v3.2 NMM Core: Eulerian passive tracer advection option

- Conservation is achieved through flux cancelations, *not* forced *a posteriori*
  - for cyclic, closed domain or rigid wall boundary conditions
- Quadratic conservative advection scheme coupled with continuity equation
  - Crank-Nicholson for vertical advection
  - Modified Adams-Bashforth for horizontal advection
  - Provides tracer mass conservation
- Advection of square roots of tracers (c.f. Schneider, MWR 1984) provides positive definiteness
- Monotonization is achieved with *a posteriori* forced conservation to correct oversteepening
- Affordable

New to WRF v3.2 NMM Core: Eulerian passive tracer advection option

- Affordable Cost
  - Faster than the original Lagrangian scheme per time step, BUT
  - Overall slower than the Lagrangian scheme due to shorter advection step
  - Stable with longer time steps (2 times), appears safe for standard model tracers

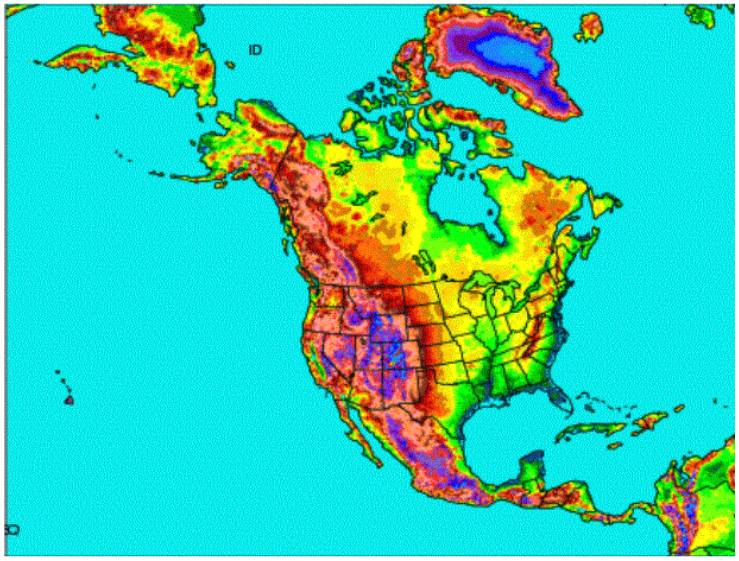
Courtesy Youhua Tang



NAM NEMS Upgrade (2011)

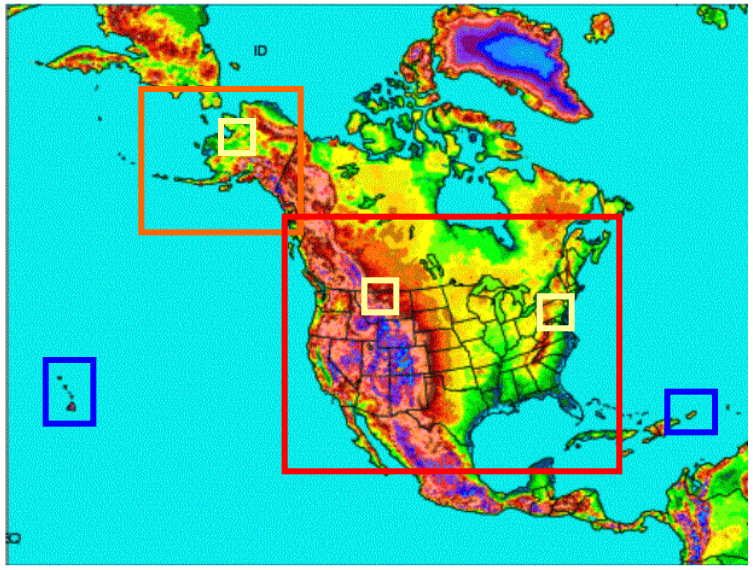
NAM

- WRF-NMM (E-grid)
- GSI analysis
- 4/Day = 6 hr update
- Forecasts to 84 hours
- 12 km horizontal
- 60 layers with 2 mb top
- 12 hr pre-forecast assimilation period with 3hr updates (catch-up)



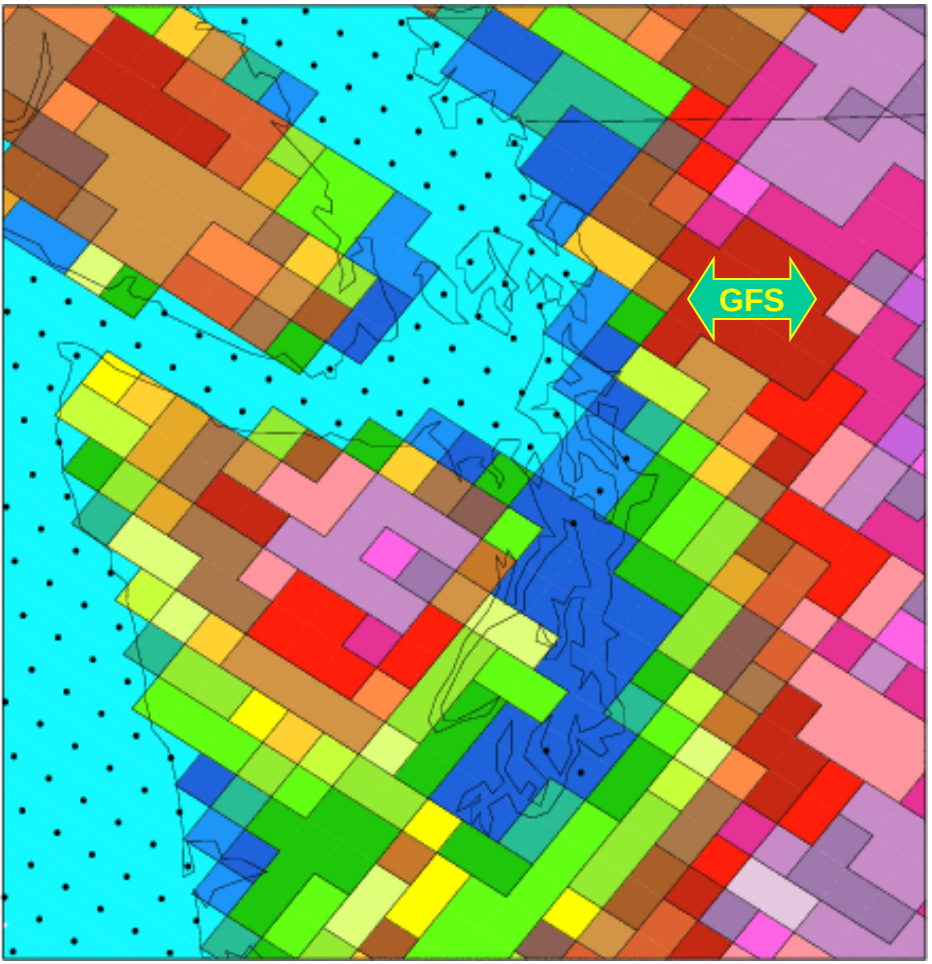
NAM

- NEMS-NMMB (B-grid)
- Parent remains at 12 km
- Multiple child nests run to 60 hr
  - **4 km CONUS nest**
  - **6 km Alaska nest**
  - 3 km Hawaii & Puerto Rico nests
- One relocateable grandchild nest run to 36 hr (CONUS or Alaska)
  - **~1-1.3 km DHS/FireWeather/IMETSupport**

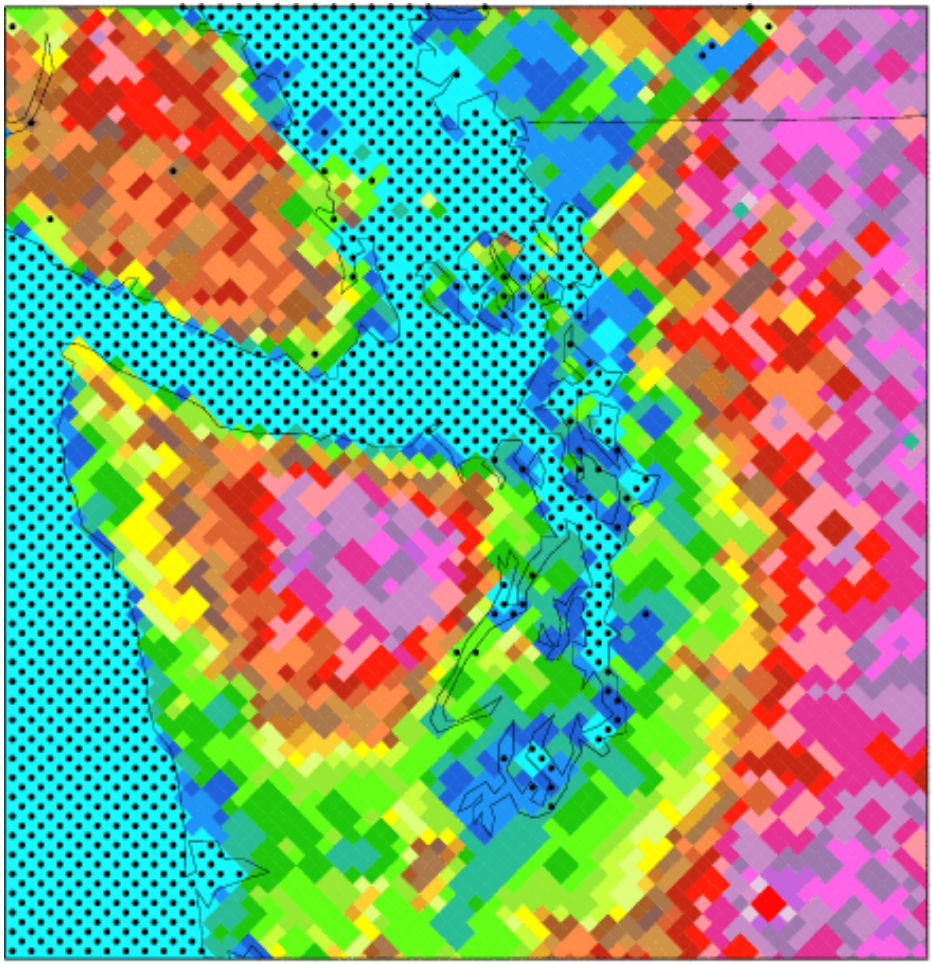


Dots represent water points Domain is Puget Sound

12 km Terrain



4 km Terrain



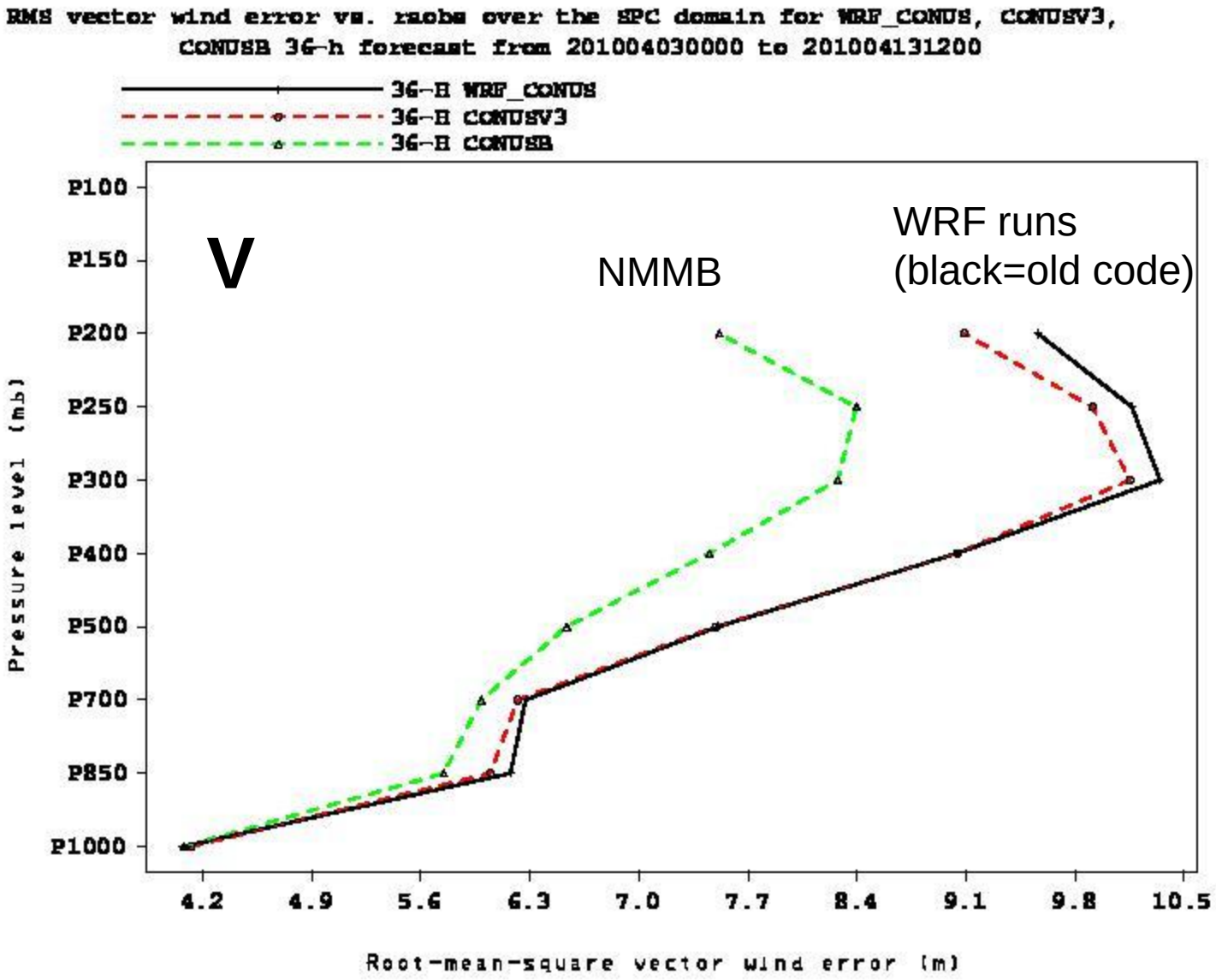
Zavisa Janjic's NMMB

- NMMB = Nonhydrostatic Multiscale Model on B-grid
- These are the main B grid advantages:
  - The B-grid requires narrower halos, i.e. less communications;
  - On the global scale, the polar filtering on the B-grid is more effective and the polar boundary condition is more straightforward;
  - E-grid code is more complex, indirect addressing (slower too) and is more difficult for debugging and maintenance;
  - The B-grid is better for application of the model in idealized 2D studies, e.g. in the x-z plane;
  - Streamlined physics interfaces compared to WRF infrastructure, facilitating development, debugging and maintenance.
- Other NMMB differences / enhancements
  - New Eulerian passive advection (see above)
  - New generalized hybrid vertical coordinate embodies:
    - Sangster 1960; Arakawa and Lamb 1977; "SAL"
    - Simmons and Burridge (1981) "SA" + Eckerman (2008)
    - Hybrid used by GFS
  - WRF & GFS physics options available

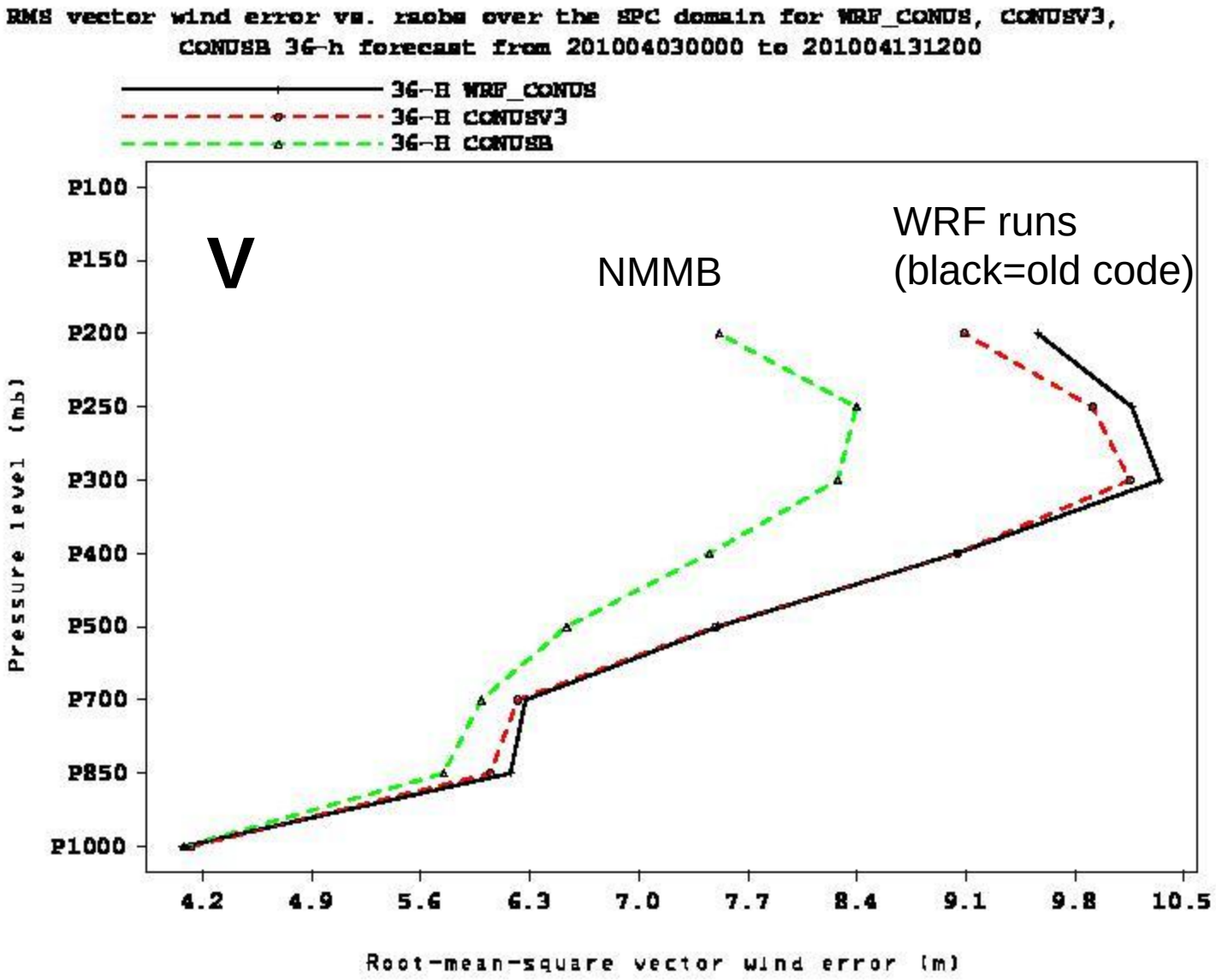
Early 4 km NMMB Impressions

- The NEMS/NMMB code used in CONUS 4 km run was tested from up-to-date SVN repository version (radiation bug fixes, multiple boundary rows, …)
- Tested 3-13 April 2010, Verified 36 hr forecasts:
  - Upper-level stats much better relative to WRF-NMM since this update.
  - Precip bias at high end improved over latest HiResWindow WRF-NMM v3.2 using the new passive advection.

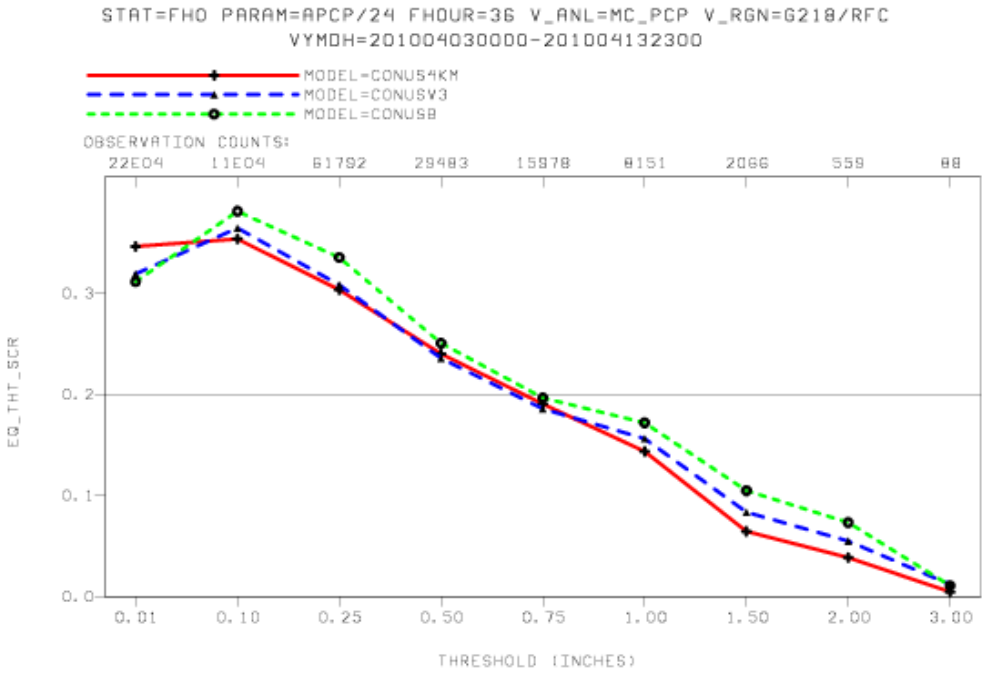
Upper Level Wind Fit to RAOB

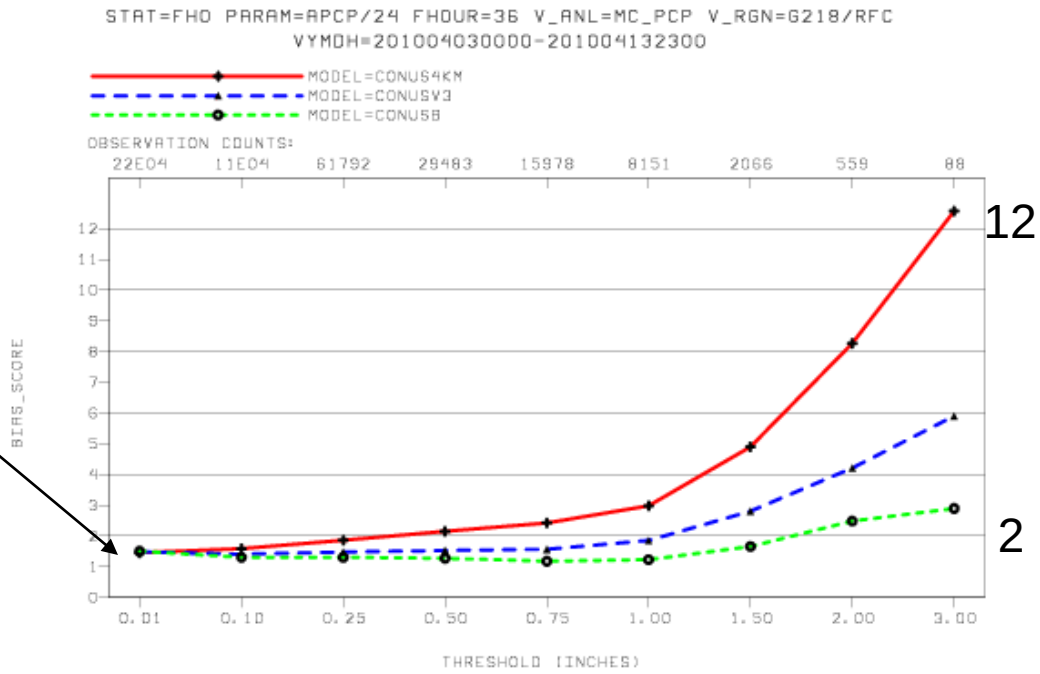


Upper Level Temperature Fit to RAOB



24hr QPF Stats





All have bias ~= 1.5 at .01”/24 h threshhold

12

2

0403 - 0413 CONUS 4 km runs, 12-36 h precip

old WRF

new WRF

NMMB

NAM/NEMS/NMMB/Nesting

Parallel Test Pages

Web Page	Models Displayed	Forecast Length	For freq
4 km WRF-NMM Parallel - 00z cycle 4 km WRF-NMM Parallel - 12z cycle	WRF-NMM (CONUS domain), WRFV2.2+ code	36-h	1 hour
4 km WRF-NMM Parallel - 00z cycle	WRF-NMM (CONUS domain), WRFV3.1 code, Eulerian passive-substance advection	36-h	1 hour
4 km NEMS-NMMB Parallel - 00z cycle	NEMS-NMMB (CONUS domain), Eulerian passive-substance advection	36-h	1 hour
12 km NEMS/NMMB North American Mesoscale Parallel (Ops NAM vs NAMB)	Ops NAM (WRF-NMM), NEMS/NMMB (North American domain)	84-h	3 hour
12 km NEMS/NMMB North American Mesoscale Parallel (NAMB vs NAMX)	NEMS/NMMB parallels (NAMB vs NAMX)	84-h	3 hour
12 km NEMS/NMMB North American Parent run vs 6 km Alaska Nested run (parent=NAMX parallel), 00z cycle	NAMX, Alaska 6 km Nest	60-h	3 hour
12 km NEMS/NMMB North American Parent run vs 4 km CONUS Nested run (parent=NAMX parallel), 12z cycle	NAMX, CONUS 4 km Nest	60-h	3 hour
Operational NAM and Parallel NAM (NAMB) - Forecast Trends over CONUS/North America	Ops NAM, parallel NAM	84-h	12 hour
Parallel NAM (NAMB and NAMX) Forecast Trends over CONUS/North America	parallel NAM runs (NAMB, NAMX)	84-h	12 hour

NAM/NEMS/NMMB/Nesting Some Testing Tidbits

- Using multiple boundary transition rows along lateral boundaries
- Advecting individual hydrometeor fields in Ferrier produced & use of WSM6 instead (expensive) had little benefit – lots more testing planned
- Adding 10 extra levels had too small a payoff so will only redistribute existing 60 levels to have a bit more resolution above the tropopause
- Will likely use ‘a small amount’ of parameterized convection (deep and shallow) in the NAM nests but will strive to preserve mesoscale structure
- We want to use RRTM, but must thoroughly test

NAM/NEMS/NMMB/Nesting More Testing Nibblets

- Will use higher res MODIS etc. land info
- Will use 1/12th degree high-resolution SST
- Will use FLAKE (2-parameter fresh water lake model) where we don't get RTG_SST_HR values [any help getting values for those 2 parameters?]
- In the FWIS 1-1.3km nests, will tweak land conditions to reflect (0th-1st order) fires (Ek)
- Will use Windsat, ACARS moisture, NOAA-19 hirs&amsu-a, IASI radiances, NASA AQUA amsu-a, GPS-RO, better VAD winds, more mesonets and more metadata.

NOAA Environmental Modeling System = NEMS

- Support for ESMF has moved from NCAR/SCD to NOAA/ESRL
- NEMS being built upon only highest levels of ESMF to keep dependence to a minimum
- Physics options will include those of WRF and GFS
- All major modeling systems in NCEP Production suite to run in NEMS:
  - GFS: global weather & climate (CFS) version coupled to ocean (HYCOM) & NOAH LSM & NMMB
  - NMMB: global and regional [for NAM], run NAM concurrent with GFS within single executable, run nested within GFS or itself, couple to Chem (WRF-CHEM or CMAQ or GOCART etc) to LSM and/or to ocean/wave, contribute to NARRE/HRRRE
  - Rapid Refresh: GSD will adapt WRF-ARW to NEMS, couple to Chem, contribute to NARRE/HRRRE
  - FIM: GSD will adapt FIM to NEMS, couple to its Chem, contribute to global ensemble suite
  - HYCOM, Hurricane, Ensemble, Data Assimilation …
- In their Operations-to-Research role, the DTC will support NEMS to the community, including a tutorial. First version to be based on 2011 NAM upgrade.

2012-2013

North American Rapid Refresh ENSEMBLE (NARRE)

- NEMS-based NMMB/ARW models & GSI analysis
- Common NAM parent domain at 10-12 km
- Initially ~6 member ensemble made up of equal numbers of NMMB- & ARW-based configurations
- Hourly updated with forecasts to 24 hours
- NMMB & ARW control assimilation cycles with 3 hour pre-forecast period (catch-up) with hourly updating
- NAM & SREF 84 hr forecasts are extensions of the 00z, 06z, 12z, & 18z runs.

2012-2013

High Resolution Rapid Refresh ENSEMBLE (HRRRE)

- Each member of NARRE contains
  - 3 km CONUS and Alaskan nests
  - Control runs initialized with radar data
- Positions NWS/NCEP/ESRL to
  - Provide NextGen Enroute A N D Terminal guidance
  - Provide PROBABILITY guidance
  - Improve assimilation capabilities with radar & satellite
  - Tackle Warn-on-Forecast as resolutions evolve towards ~1 km
- NAM nests are extensions of the 00z, 06z, 12z & 18Z runs.
- HRRRE subsumes the current experimental VSREF
- Control members likely to make up core of Analysis of Record

Both NARRE and HRRRE Require Bigger NCEP Computer

Very Short Range Ensemble Forecast (VSREF) System

[courtesy of Binbin Zhou]

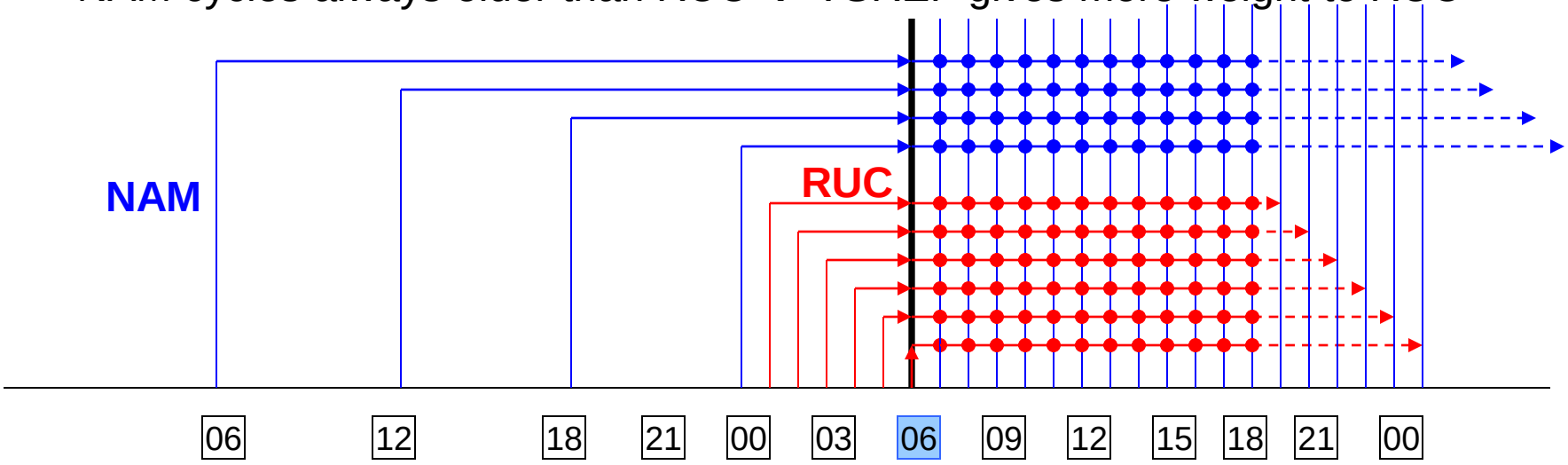
Example: Ensemble member combination for 06th cycle run

4 NAM cycles, weighted 0.7, 0.5, 0.3, 0.1, respectively

6 RUC cycles, weighted 1.0, 0.9, 0.8, 0.7, 0.6, 0.5, respectively

Forecast hour extended to 12 hr (with extension of RUC forecasts to 18hr)

NAM cycles always older than RUC → VSREF gives more weight to RUC



06Z cycle VSREF's ensemble member configuration