NCEP

WRF-NMM & GSI Analysis To Replace Eta Model & 3DVar in NAM Decision Brief

Mesoscale Modeling Branch

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where the nation's climate and weather services begin

What Is Being Proposed

- Major Components of Upgrade Package for NAM
  - Replace Eta Model with WRF version of NMM (Nonhydrostatic Mesoscale Model -- also in DGEX)
    - WRF Common Modeling Infrastructure
    - Non-hydrostatic dynamics
    - Use of hybrid sigma-pressure vertical coordinate with top at 2 mb
    - Refined advection, diffusion, numerics and physics
  - Replace Eta 3D-Var analysis with Gridpoint Statistical Interpolation (GSI) analysis
    - Unified (regional + global) 3D-Variational analysis adapted to WRF
    - Begin use of background errors based on WRF-NMM to 2 mb
    - Use of new variable for moisture analysis
    - Use of tendency in constraint terms
    - Use of dynamically retuned observational errors

What Else Is Being Proposed

- Model initialization
  - Use of new unified (regional + global) package (George Gayno) for bringing in external fields for WRF-NMM
  - Begin use of high resolution ($1/12^{th}$ degree) SST
  - Begin use of high resolution (4 km) snow
  - Common specification of terrain, land-sea mask
- Data assimilation changes
  - Use of bias-corrected observed precipitation analysis values in land-surface physics (but without nudging T, moisture & cloud)
  - Start assimilating WSR-88D Level II radial wind data
  - Start assimilating GPS-Integrated Precipitable Water (IPW)
  - Start assimilating NOAA-18 radiances
  - Drop use of GOES Precipitable Water retrievals
  - Drop use of SSM/I Total Precipitable Water retrieval

What Else Is Being Proposed

- Product changes - added various output parameters required by NWS regions, NCEP service centers, Air Quality Forecast system
  - Simulated radar reflectivity
  - Height of the top of the planetary boundary layer
  - Vertical velocity dz/dt
  - Ceiling height
  - Instantaneous clear sky incoming SW flux at the surface
  - Instantaneous outgoing LW flux at the top of the atmosphere
  - Dominant precipitation type (replaces Baldwin)
  - Pressure of LCL
  - Total column integrated supercooled liquid water and melting ice
  - Base and top heights of supercooled liquid water layer
  - GOES IR look-alike

Who Was Involved

- Visiting Scientists
  - Zavisa Janjic
- Government Scientists
  - Tom Black
  - John Derber
  - Dennis Keyser
  - Ying Lin
  - Geoff Manikin
  - Jeff McQueen
  - Ken Mitchell
  - Dave Parrish
  - Eric Rogers
  - Wan-Shu Wu
- Contractor Scientists
  - Hui-Ya Chuang
  - Mike Ek
  - Brad Ferrier
  - George Gayno
  - Dan Johnson
  - Dusan Jovic
  - Manuel Pondeca
  - Matt Pyle
  - Perry Shafran
  - Marina Tsidulko
  - Vince Wong
  - Binbin Zhou

Pre-WRF NMM Chronology

- 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: On-Call Emergency Response (HYSPLIT) capability begins using 4 km NMM
- July 2002: HiResWindow runs upgraded; 8 km NMM replaces use of 10 km Eta
- May 2003: Fire Weather / IMET Support runs implemented using 8 km NMM

WRF-NMM Chronology

- April 2004: NSSL/SPC Spring Program, highly successful development runs of 4.5 km WRF-NMM with explicit convection
- September 2004: HiResWindow runs, 8 km WRF-NMM replaces pre-WRF NMM
- June 2005: HiResWindow upgraded to use 5 km WRF-NMM with explicit convection
- December 2005: Short Range Ensemble Forecasting system adds three members based on 40 km WRF-NMM

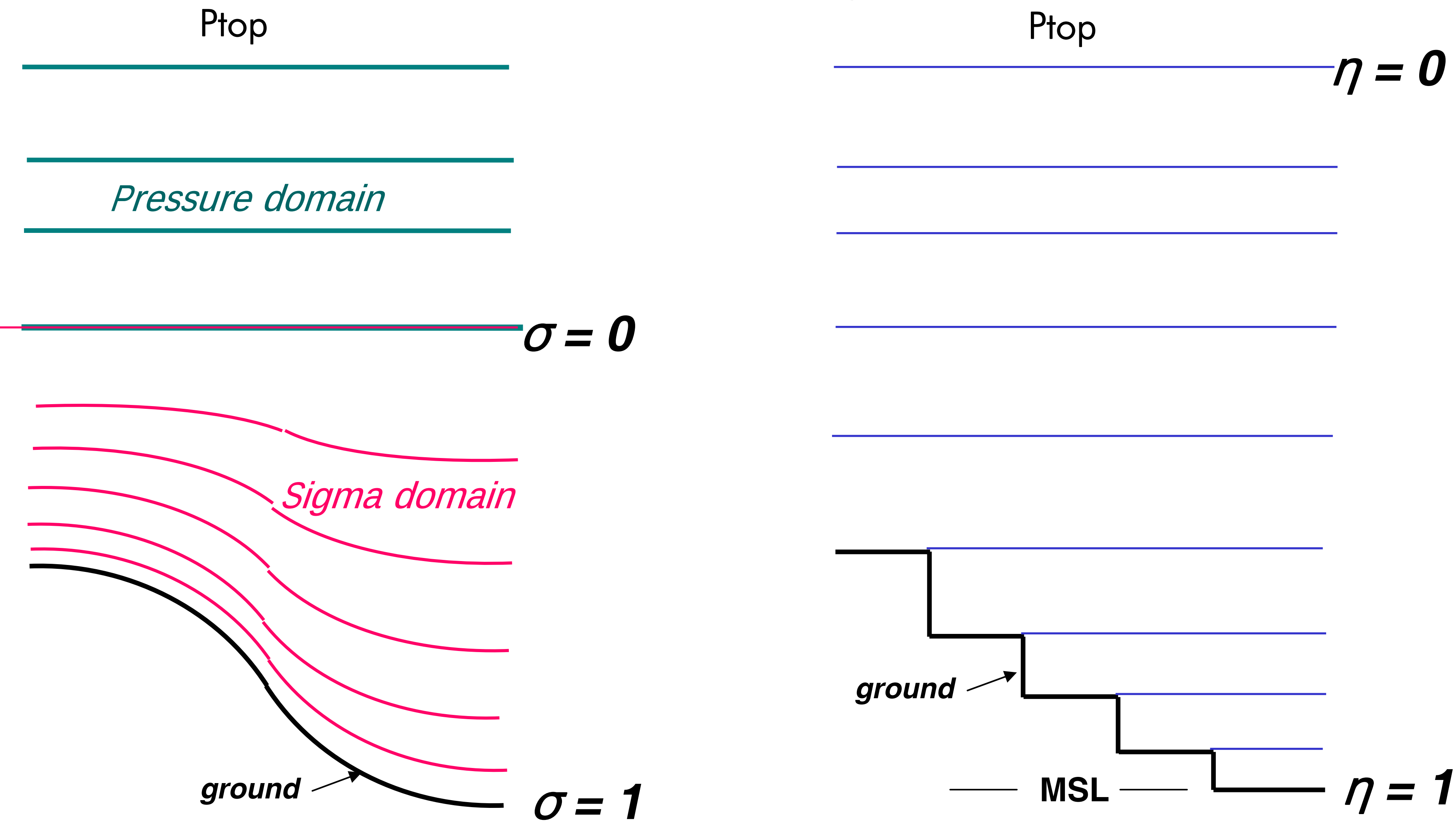
Basic Feature Comparison (for NAM): WRF-NMM vs Meso Eta Model

Feature	Meso Eta Model	WRF-NMM
WRF Common Modeling Infrastructure	No	Yes – allows faster tech transfer and partnering with community
Dynamics	Hydrostatic	Hydrostatic + efficient treatment of complete nonhydrostatic corrections
Horizontal grid spacing	12 km semi-staggered E-grid rotated lat/long projection	12 km semi-staggered E-grid rotated lat/long projection – **identical**
Domain	North America	North America – **identical**

Basic Feature Comparison (for NAM): WRF-NMM vs Meso Eta Model

Feature	Meso Eta Model	WRF-NMM
Vertical coordinate	60 step-mountain eta layers	60 hybrid sigma-pressure layers
Top pressure	25 hPa	2 hPa
Gridscale Terrain	Unsmoothed with peak (silhouette) and valley enhancement, lateral boundaries set to sea-level	Lightly smoothed, grid-cell mean everywhere
Sub-gridscale terrain effects	Form drag – Zo effective from terrain variability	Zo depends on elev, subgrid variability & vegetation type
Gravity wave drag	No	No

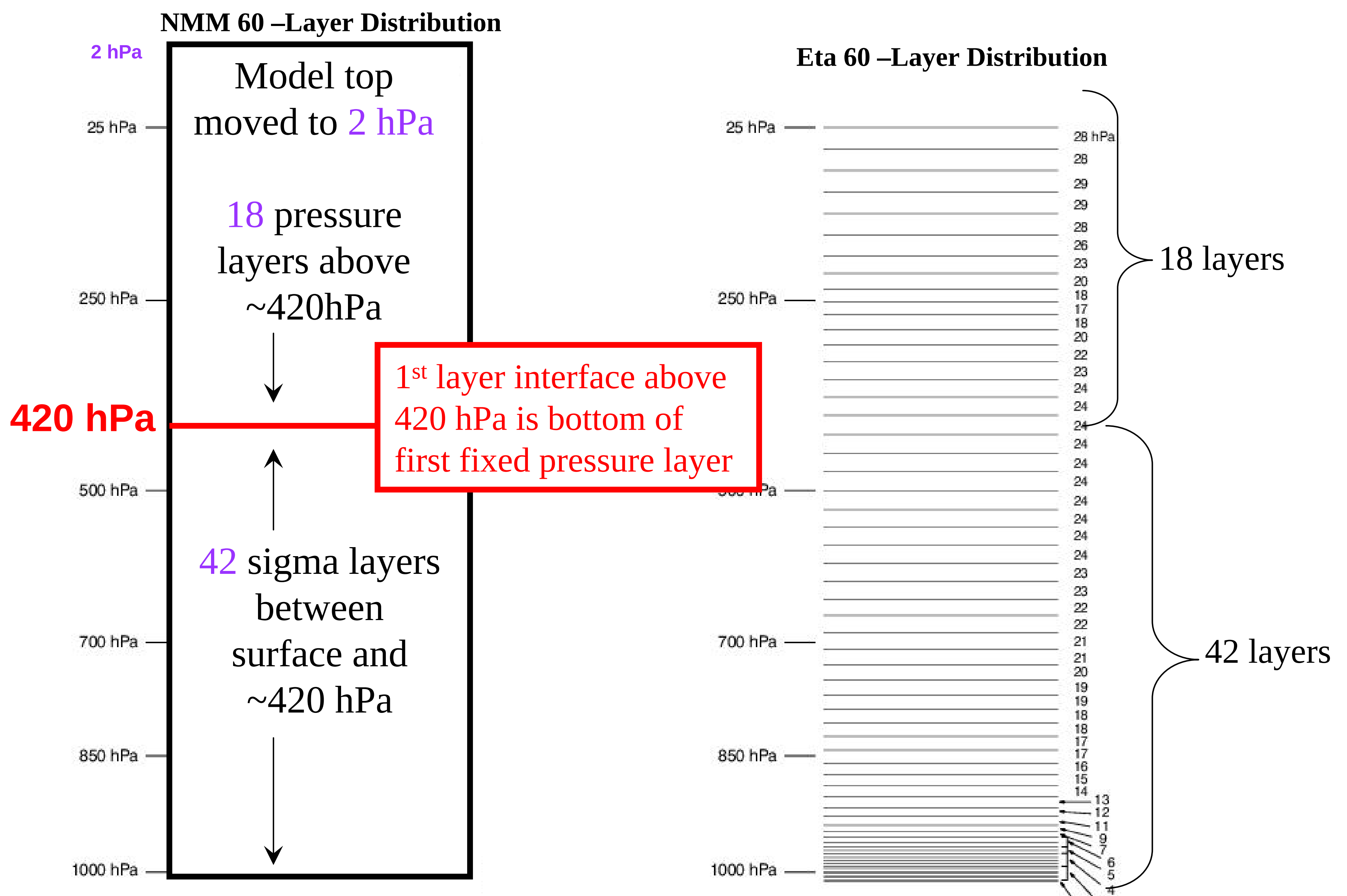
Hybrid vs Step (Eta) Vertical Coordinate Systems



HYBRID

Step (Eta)

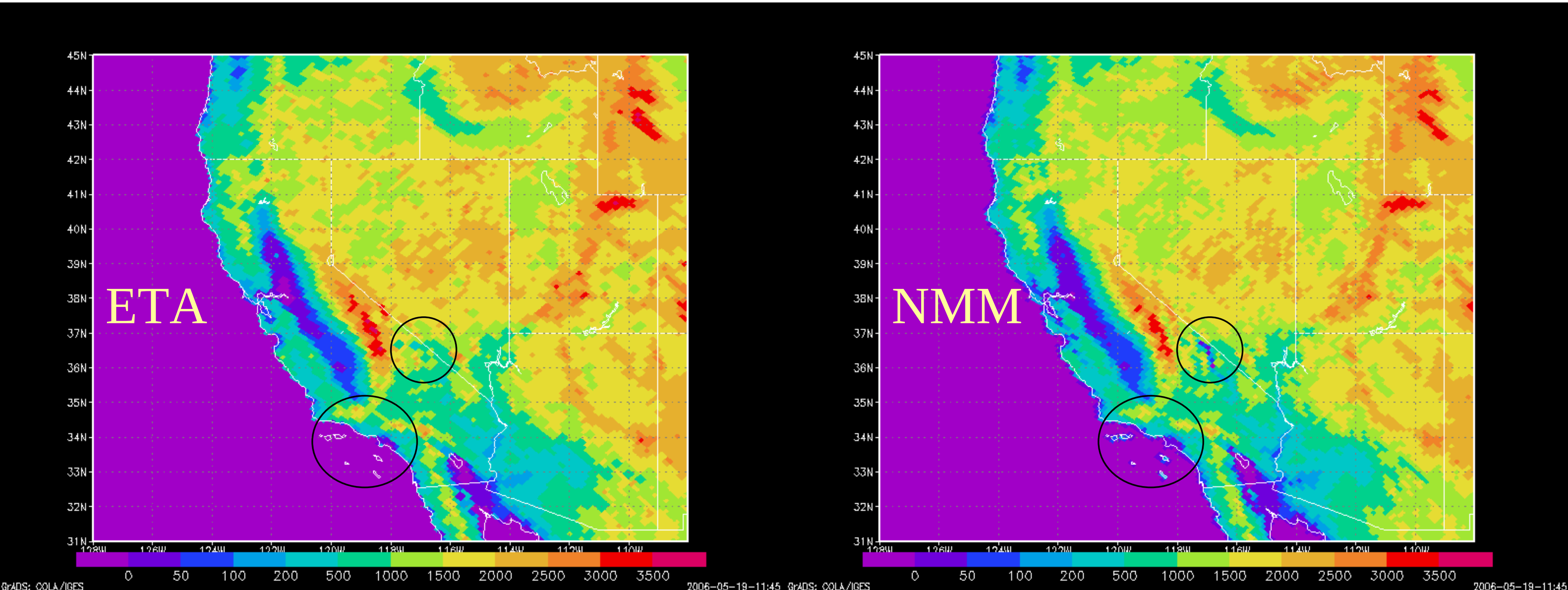
NMM Vertical Domain Compared to Eta



1st layer **40 m** at sea-level then **thinner** 1st layer 20 m at sea-level then **thicker**

Eta versus NMM Terrain

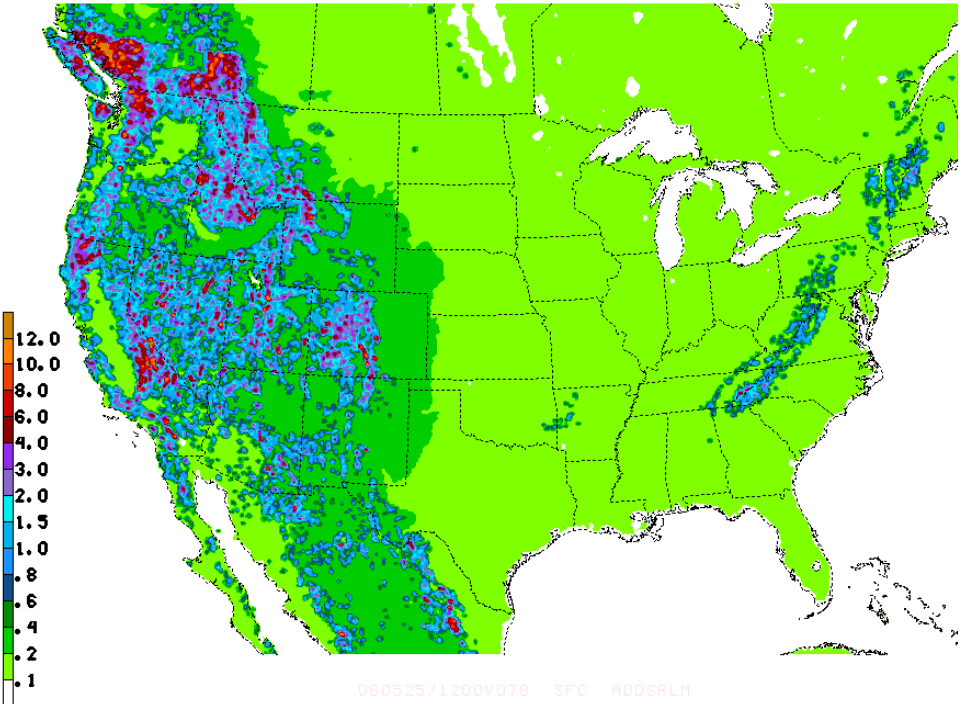
- Based on global 30-arc second USGS dataset.
- Model terrain height is the average of the USGS values located within the grid box.
- Isolated mountain peaks smoothed with 5-point filter.
- Differences with Eta silhouette terrain are small.



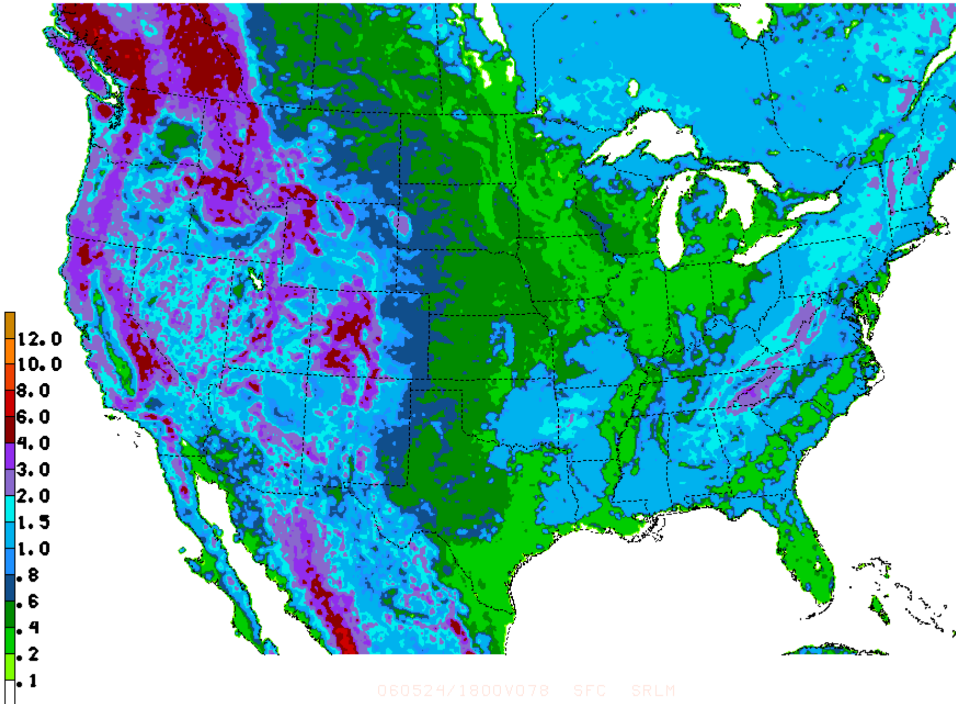
Zo Comparison Eta vs WRF-NMM

- Local maximum values are higher with the NAM-Eta treatment, but much greater coverage of reasonably large Zo values (> 1 meter) in the NAM-WRF.

Eta



WRF-NMM



Basic Feature Comparison (for NAM): WRF-NMM vs Meso Eta Model

Feature	Meso Eta Model	WRF-NMM
Timesteping schema: fast / inertial gravity waves	forward-backward (Mesinger, 1974) for inertial gravity wave adjustment 30 sec	forward-backward (Janjic, 1979) for all fast waves 26.7 sec Implicit for vertically prop. sound waves
Timesteping schema: advection	first-forward then off-centered 60 sec Turbulence and moist processes 300 sec	T,u,v: horizontal Adams-Bashforth,vertical Crank-Nicholson off-cntr 26.7sec TKE, water species: Explicit, iterative, flux-corrected 53.3 sec Turbulence and moist processes **160 sec**

Basic Feature Comparison (for NAM): WRF-NMM vs Meso Eta Model

Feature	Meso Eta Model	WRF-NMM
Horizontal Advection schema	T, u, v, TKE: energy and enstrophy conserving, quadratic conservative, 2^{nd} order (Janjic, 1984) Water vapor and cloud water: upstream, flux-corrected, positive definite, conservative (Janjic, 1997)	T, u, v: energy and enstrophy conserving, quadratic conservative, 2^{nd} order (Janjic, 1984) TKE, water vapor and total condensate: upstream, flux-corrected, positive definite, conservative (Janjic, 1997)

Basic Feature Comparison (for NAM): WRF-NMM vs Meso Eta Model

Feature	Meso Eta Model	WRF-NMM
Vertical Advection schema	T, u, v, TKE: quadratic conservative, 2nd order Water vapor and cloud water: piecewise linear (Mesinger and Jovic, 2002)	T, u, v: quadratic conservative, 2nd order TKE, water vapor and total condensate: upstream, flux-corrected, positive definite, conservative (Janjic, 1997)

Basic Feature Comparison (for NAM): WRF-NMM vs Meso Eta Model

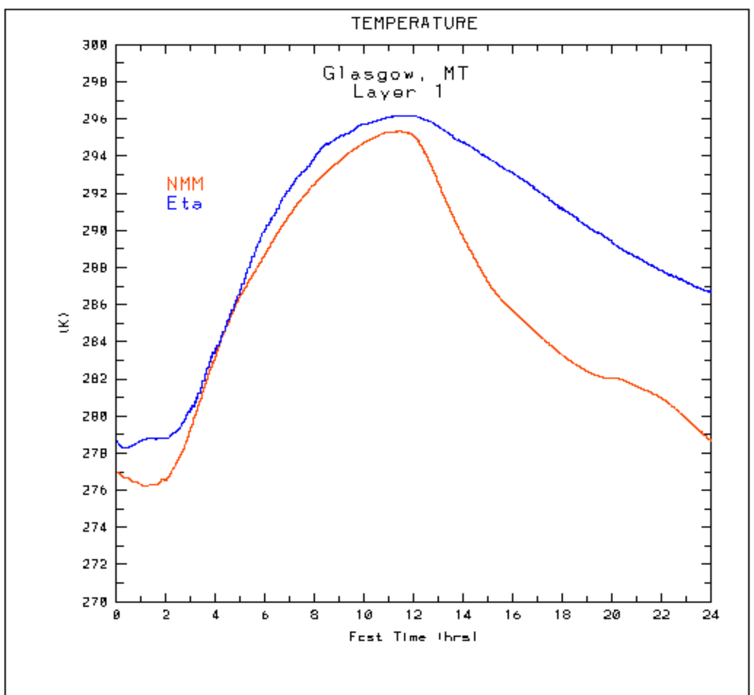
Feature	Meso Eta Model	WRF-NMM
Horizontal Diffusion	2^{nd} order "Smagorinsky-type" COAC= .27 w/ lower limit on deformation	forward, nonlinear 2^{nd} order "Smagorinsky type" (Janjic, 1990) COAC= .075 with no limit deformation
Vertical Diffusion	Sfc layer: viscous sublayer, similarity theory Above sfc lyr: mod Mellor-Yamada Level 2.5 (Janjic,1994,1996, 2001)	Sfc layer: based on similarity theory, viscous sublayer over land/water (Janjic 1996; Chen et al. 1997) Above sfc lyr: 1-D prognostic TKE w/ local vertical mixing (Janjic,1990,1996,2001,2002)
Divergence damping	Coeff = 6.0 Grid-coupling=1.	Coeff = 5.7 Grid-coupling < 0.5

Physics Feature Comparison (for NAM): WRF-NMM vs Meso Eta Model

Physics	Meso Eta Model	WRF-NMM
PBL & Turbulent mixing	Mellor-Yamada Level 2.5 dry	Mellor-Yamada Level 2.5 w/ moist processes Density variations included (elim. Boussinesq approx.)
Surface exchange	…+ Paulson functions	…+ Holtslag and de Bruin functions Sfc heat exchange mod
Land-Surface	NOAH LSM with 4 soil layers May 2005 "glitch"	NOAH LSM with 4 soil layers Fixed glitch

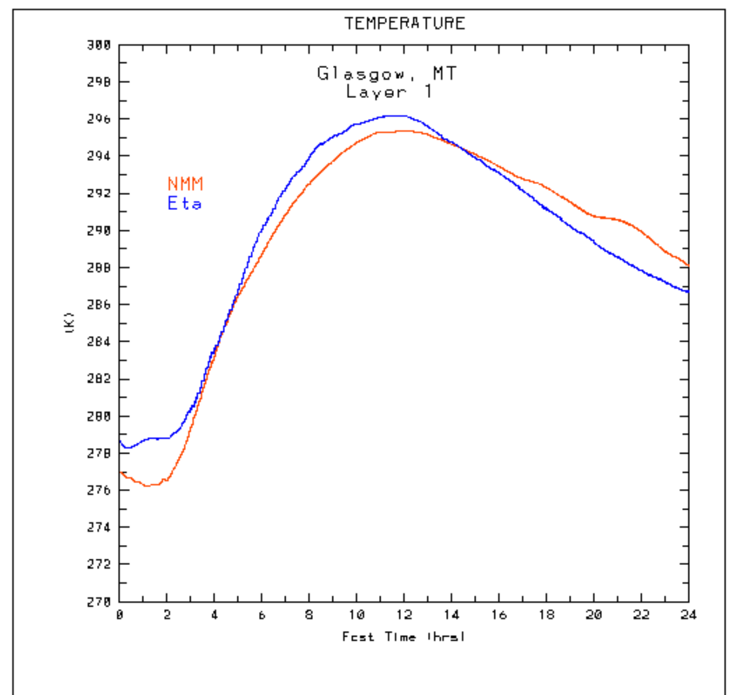
NMM Sfc Heat Exchange Modification

- Surface heat exchange coefficients reduced:
  - in statically-stable environments
  - particularly over elevated terrain
- Corrects NMM’s excessive low-level cooling at night, due in part to thinner sfc layer especially over mountainous terrain in the WRF-NMM.



ETA

NMM



Physics Feature Comparison (for NAM): WRF-NMM vs Meso Eta Model

Physics	Meso Eta Model	WRF-NMM
Cloud Microphysics	Ferrier, 2002 RH crit = 97.66% Auto-conversion threshold (cld->rain) .84 g/kg	Ferrier, 2002 RH crit = 100% Auto-conversion threshold (cld->rain) .42 g/kg (quicker)
Deep and Shallow Convection	Betts-Miller-Janjic Janjic, 2000	Betts-Miller-Janjic Janjic, 2000 Minor modifications

Physics Feature Comparison (for NAM): WRF-NMM vs Meso Eta Model

Physics	Meso Eta Model	WRF-NMM
Shortwave Radiation	GFDL - Lacis and Hansen, 1975 1 hr	GFDL - Lacis and Hansen, 1975 1 hour
Longwave Radiation	GFDL - Fels and Schwarzkopf, 1975 Schwarzkopf and Fels, 1985 1 hour	GFDL - Fels and Schwarzkopf, 1975 Schwarzkopf and Fels, 1985 1 hour First 2 layer tendencies averaged Radiating sfc = skin+1st
Cloud-Radiation	Partial cloudiness for Grid-Scale and/or Cu	Same but Grid-Scale more binary (sharper edges) Increased cloud emissivity

Gridpoint Statistical Interpolation (GSI)

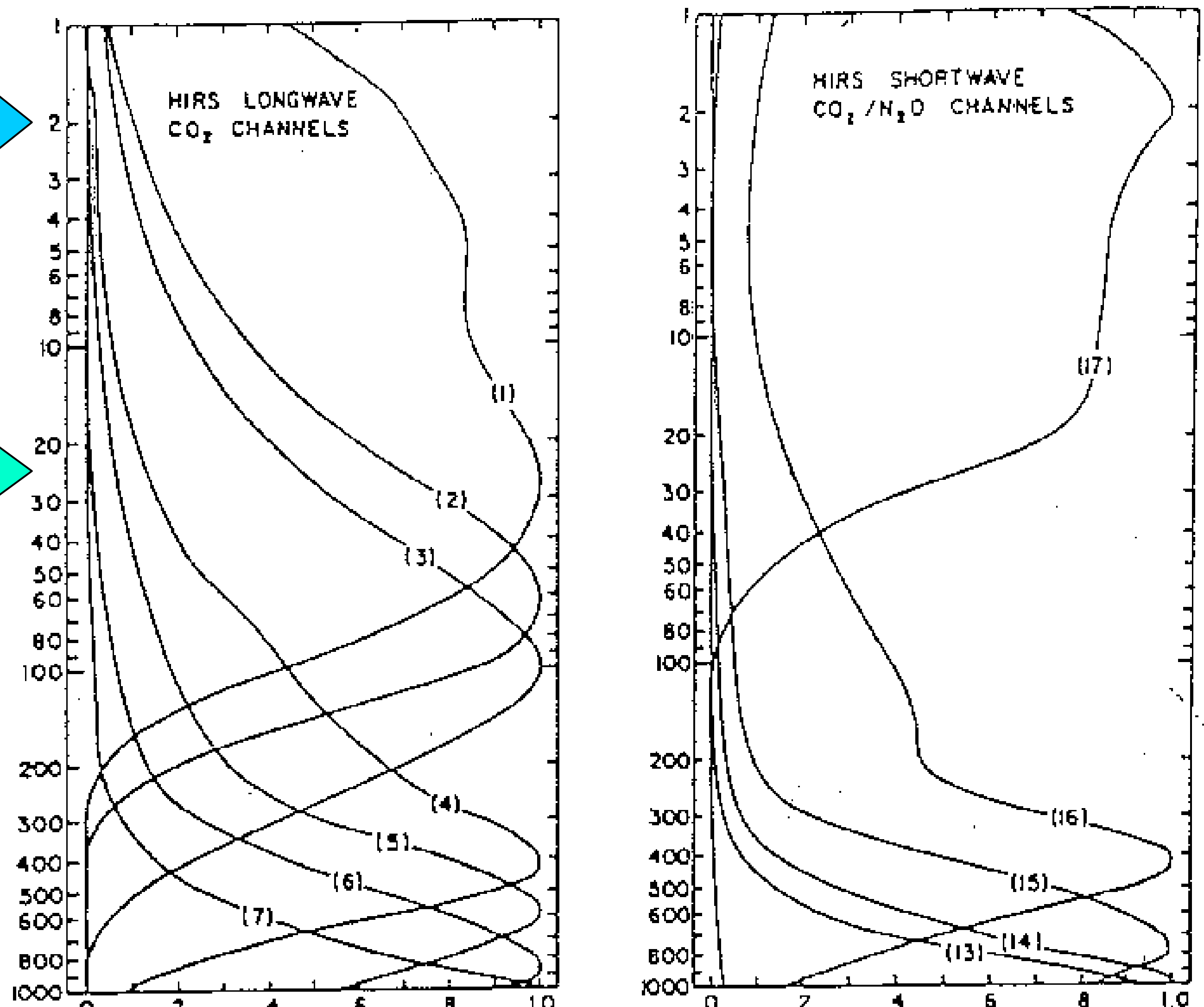
Basic Feature Comparison: Eta 3D-Var vs GSI

Feature	Eta 3D-Var	GSI
GFS & WRF Connectable	No	Yes
Unified use of satellite radiances (JCSDA)	No - OPTRANS	Yes – new CRTM
Background error	GFS based NMC method	NMM based Monte-Carlo
Normalized RH as moisture analysis variable	No – uses specific humidity	Yes
Dynamic constraint using tendencies	No - simple thermal wind	Yes
Adaptively tuned ob errors	No	Yes
Use of reported heights	No	Yes
Built-in cross-validation	No	Yes

TOVS/HIRS Satellite Channel Weighting Functions and Model Top Pressure

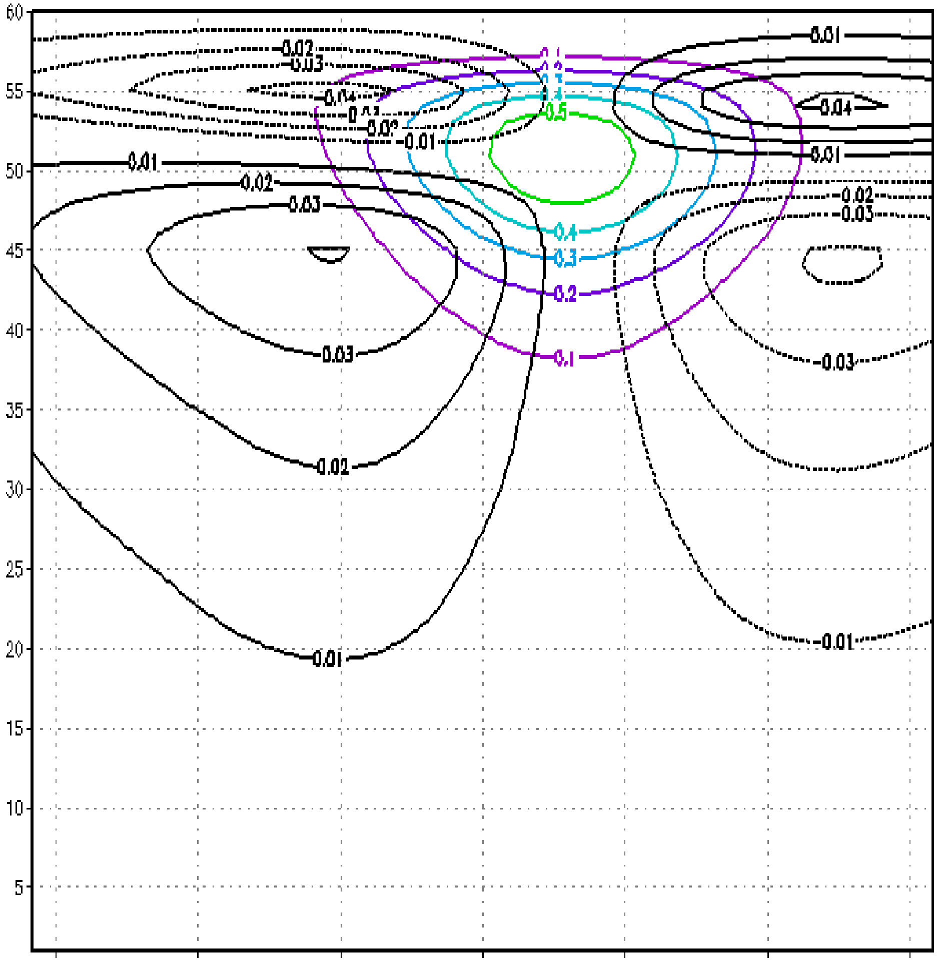
New top 2 mb

Old top 25 mb

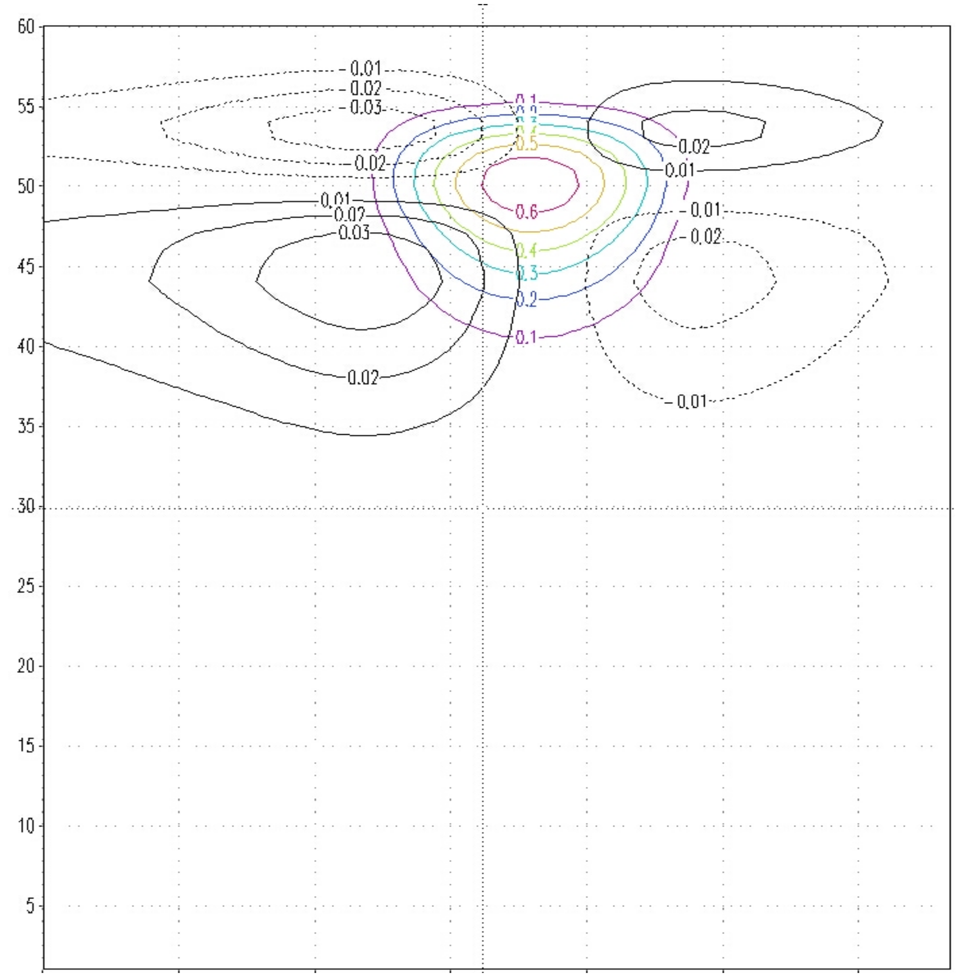


Analysis Influence of High Level Wind Increment 1 m/sec

Eta 3D-Var



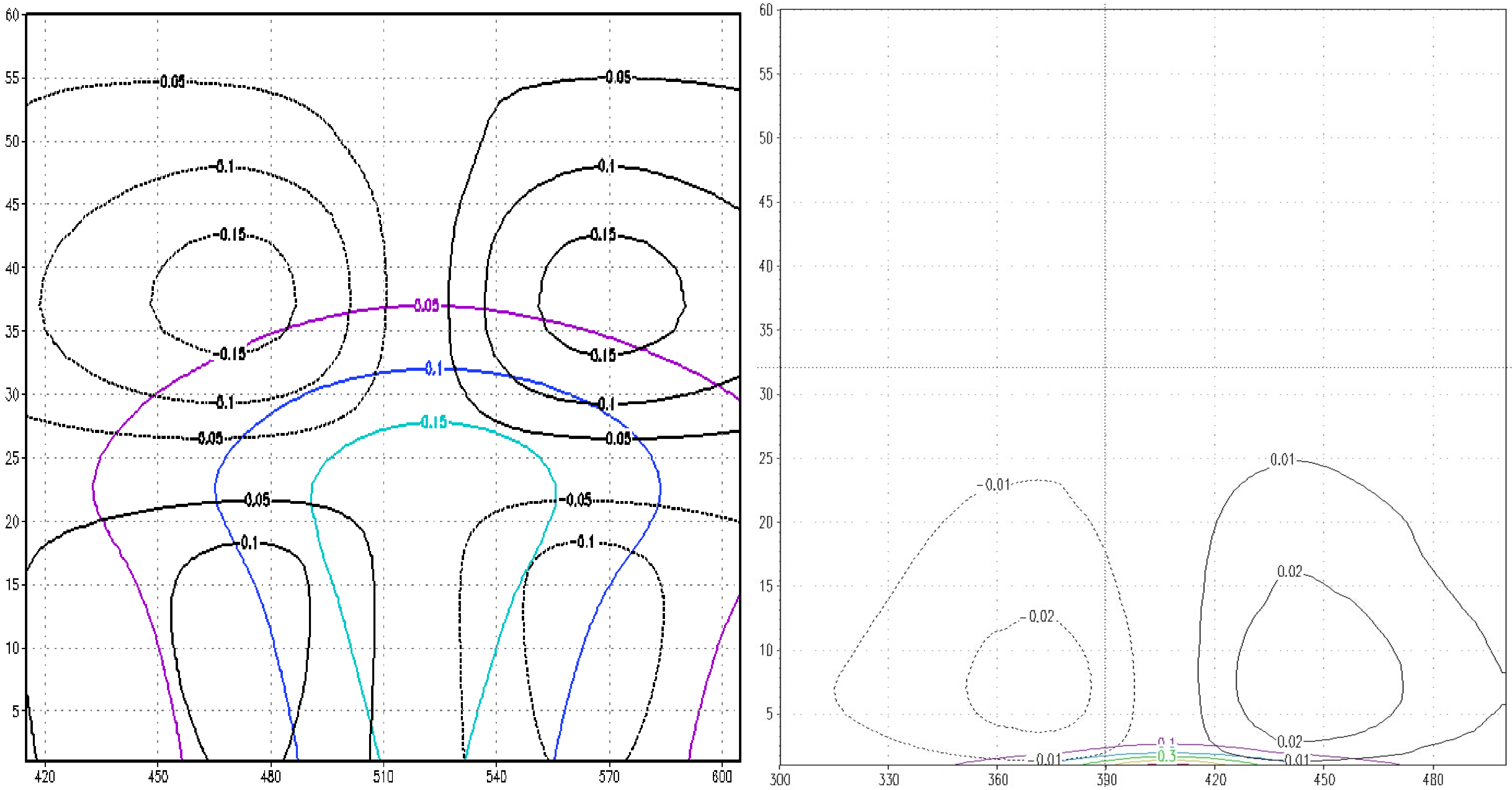
GSI



Vertical section of U increments (color contours) and corresponding T increments (black contours) of a wind ob with 1 m/s innovation at N45 and 250 mb.

Analysis Influence of Low Level Temperature Increment 1deg

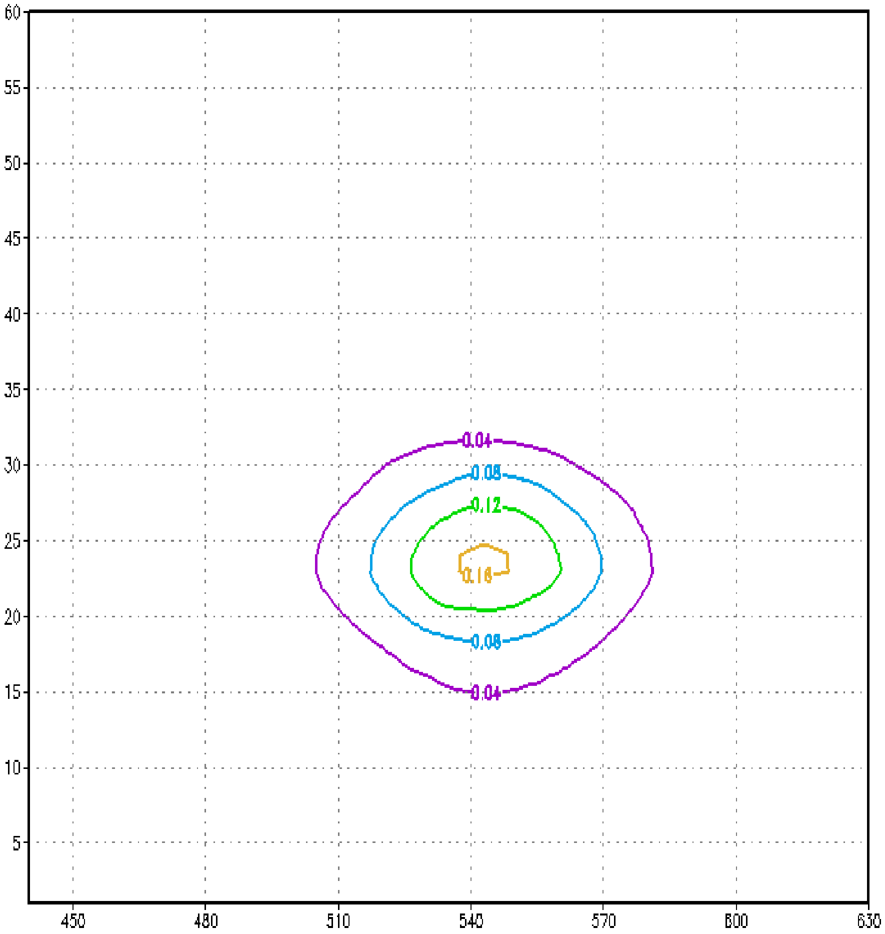
Eta 3D-Var GSI



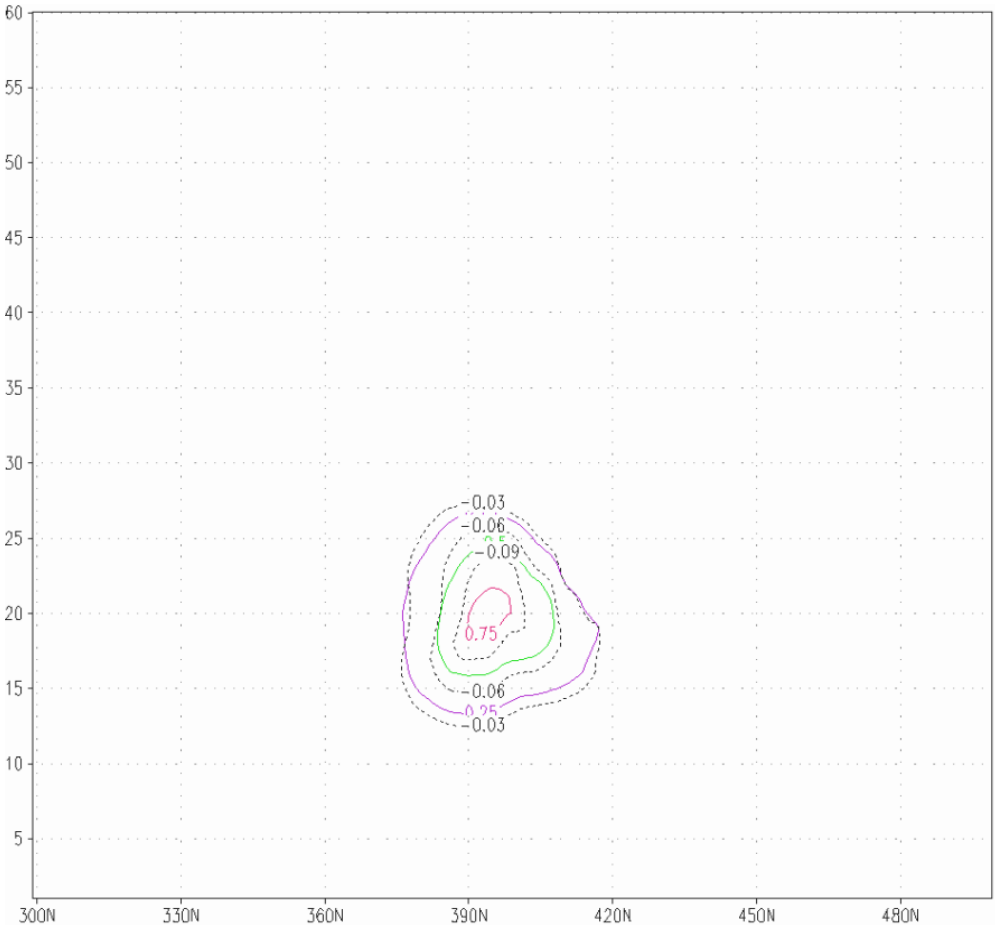
Vertical section of T increments (color contours) and corresponding U increments (black contours) of a T ob with 1 degree innovation at N45 and 1000 mb.

Analysis Influence of 850 mb Moisture Increment 1g/kg

Eta 3D-Var



GSI



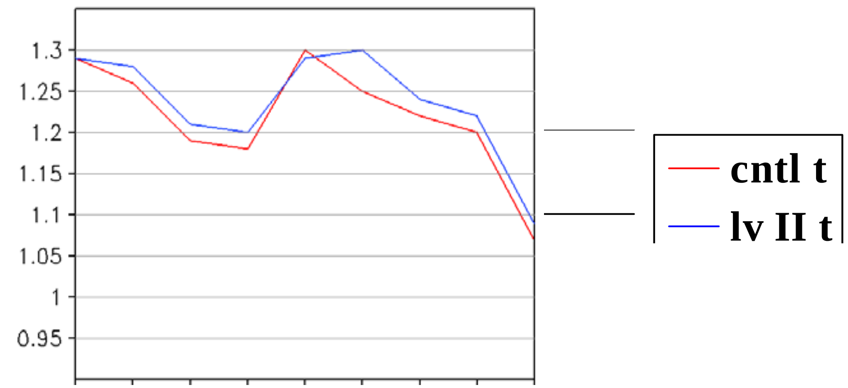
Vertical section of q increment (color contours, g/kg) for a moisture ob with 1 g/kg innovation at N45 and 850 mb.

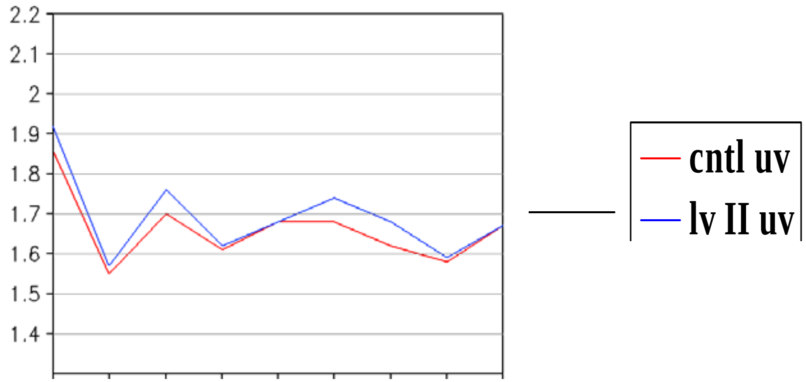
Data Usage Comparison Eta-3DVar vs WRF-GSI

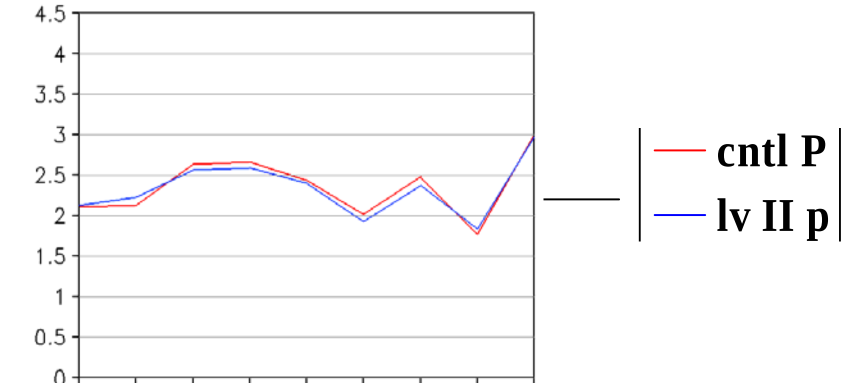
Data type	**Eta 3DVAR**	**WRF GSI**
Overland sfc temperature obs	Yes (through 2DVAR only)	No
GOES layer PW	Yes	No
SSMI TPW	Yes	No
GPS IPW	No	Yes
NOAA 18	No	Yes
Dropsonde q	No	Yes
Level II Radial Winds	No	Yes

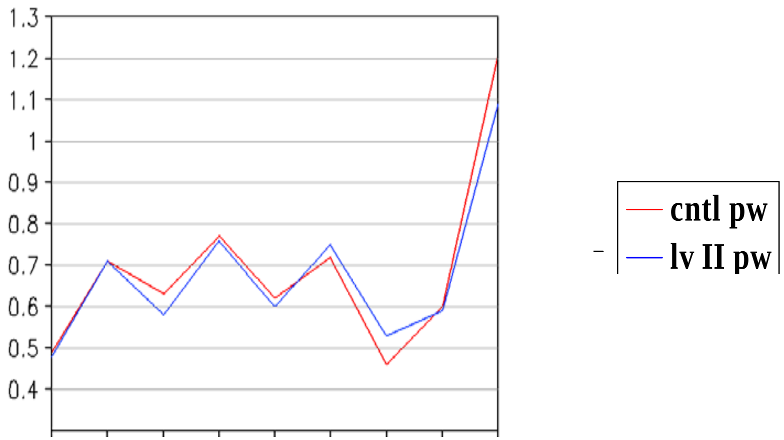
Impact of using Level II radar winds

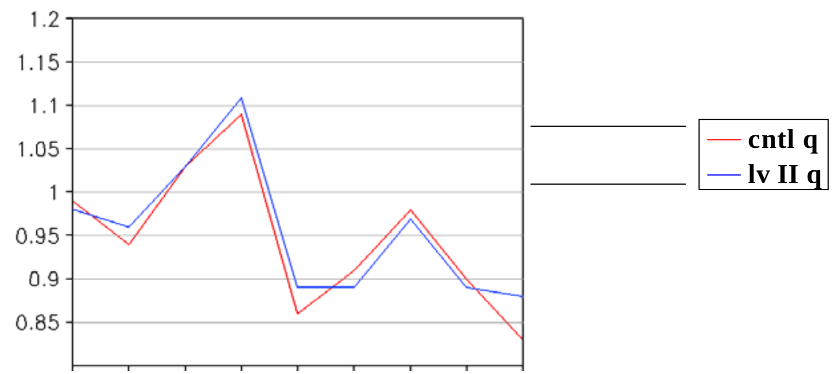
Penalty from the conventional data at end of each 12-hr cycling





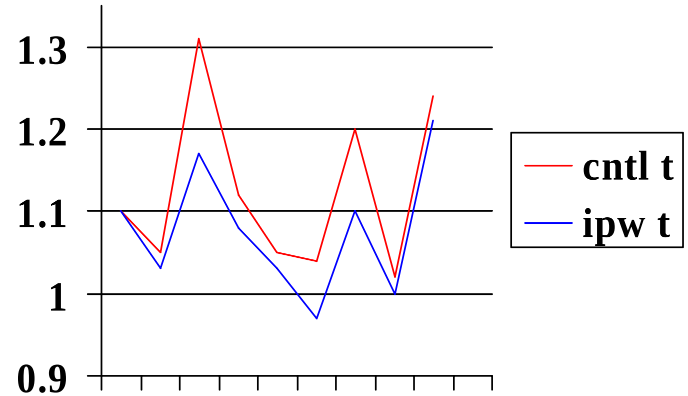


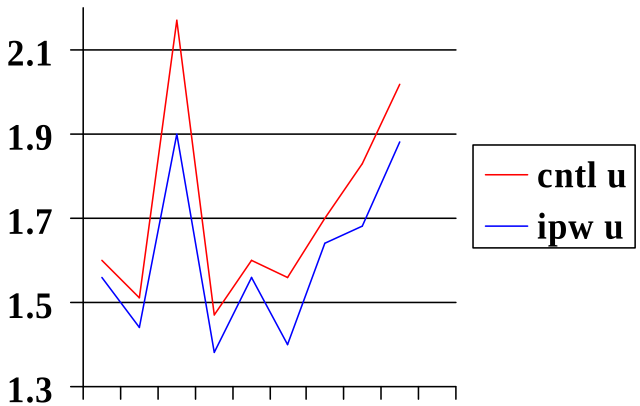


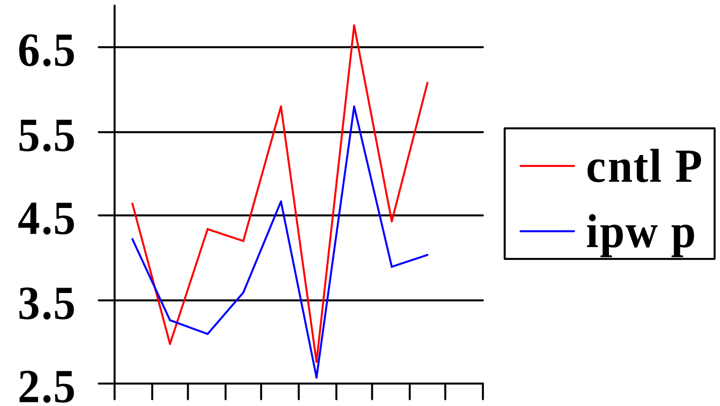


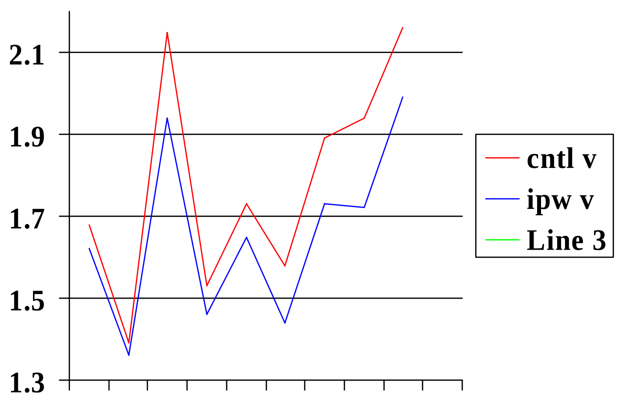
Impact of using GPS-IPW

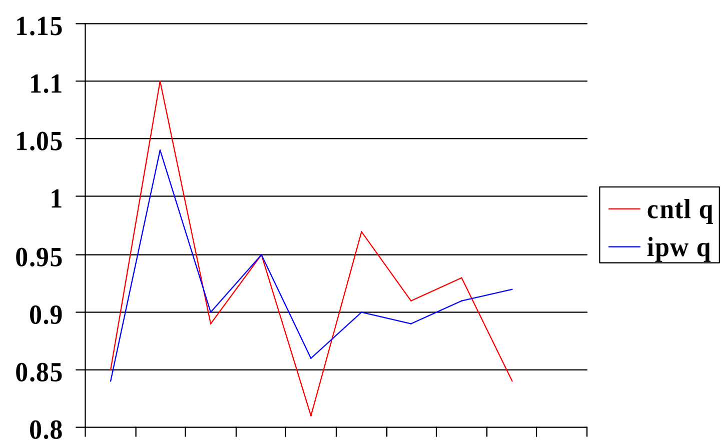
Penalty from the conventional data at end of each 12-hr cycling



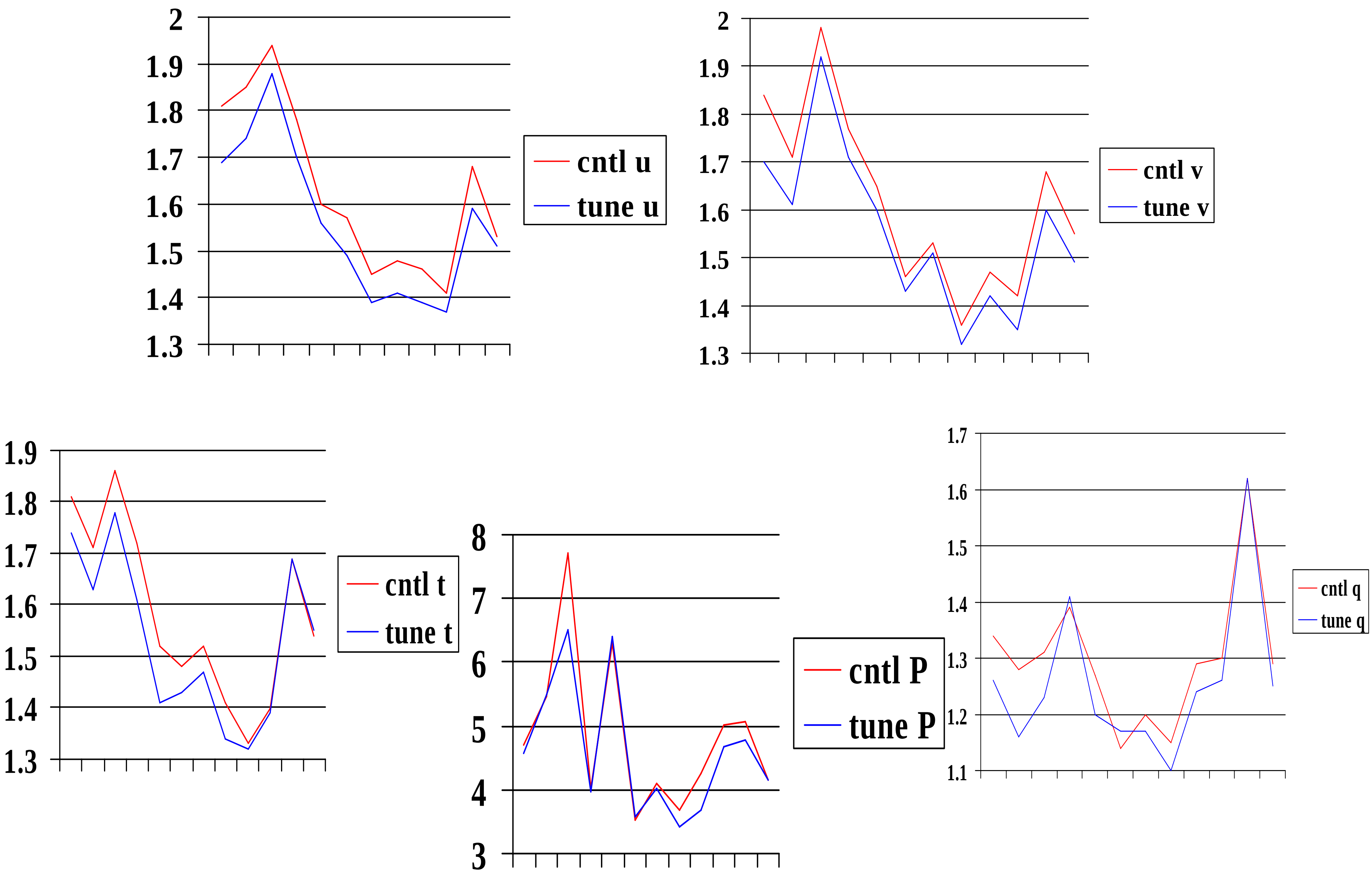








Impact of background **wind** error variance/amplitude tuning
Penalty from the conventional data at end of each 12-hr cycling



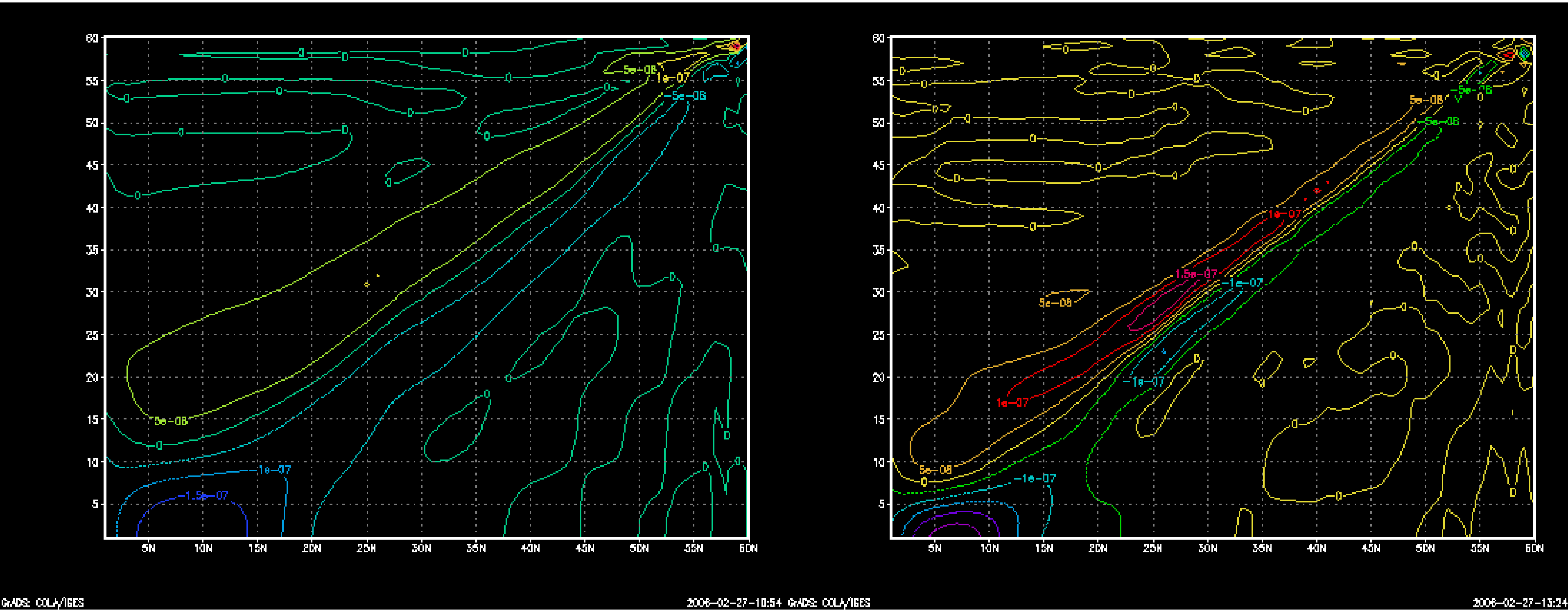
Impact of oberr tuning on forecasts

3 hr forecast RMS fit to obs at end of 12-hr cycle (cntl/exp)

blue : positive: **red** : negative

psfc	q	t	u/v
1.84/**1.71**	8.49/**7.74**	2.25/**2.11**	4.19/4.19
1.12/**1.04**	13.37/**12.94**	2.18/**2.16**	4.05/**4.03**
1.68/**1.37**	12.41/**12.17**	2.12/**2.07**	4.18/**4.11**
1.75/**1.39**	11.33/**10.82**	2.12/**2.04**	4.36/**4.29**
1.50/**1.28**	13.79/**13.23**	2.04/**1.99**	4.52/**4.50**
1.75/**1.58**	12.63/**12.21**	2.15/**2.07**	4.31/**4.24**
1.45/**1.46**	13.76/**13.50**	2.10/**2.08**	4.74/**4.64**
1.72/**1.50**	11.72/**11.55**	2.15/**2.13**	4.29/**4.31**
1.65/**1.39**	11.64/**11.52**	2.13/**2.07**	4.24/**4.14**
1.60/**1.28**	13.03/**12.58**	2.21/**2.19**	4.58/**4.61**
1.69/**1.25**	12.54/**11.98**	2.22/**2.18**	4.72/**4.69**
1.35/**1.12**	13.24/**12.71**	2.19/**2.16**	4.43/**4.48**
1.69/**1.32**	12.10/**11.75**	2.11/**2.05**	4.81/**4.76**
1.20/**1.20**	13.53/**12.15**	2.13/**1.99**	4.61/**4.50**

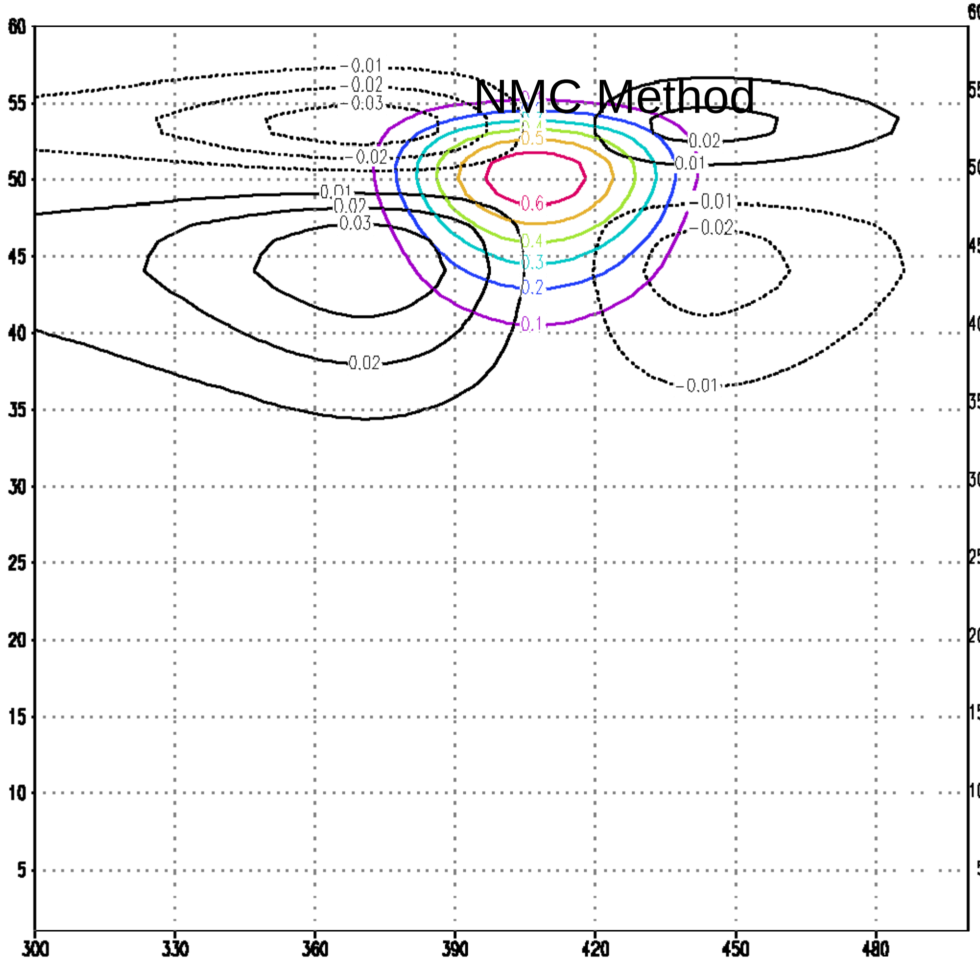
NMC method & Monte Carlo method

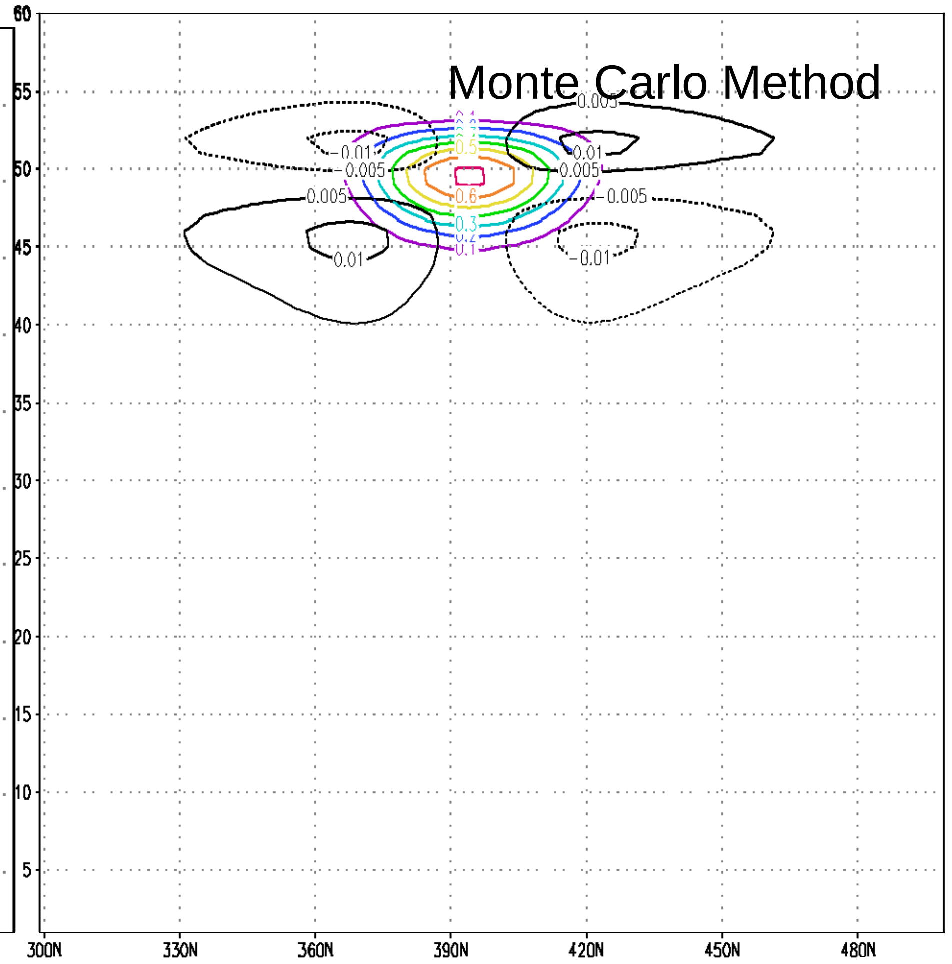


Projection matrix: stream function to temperature

The projection estimated from the Monte Carlo method is more compact and localized.

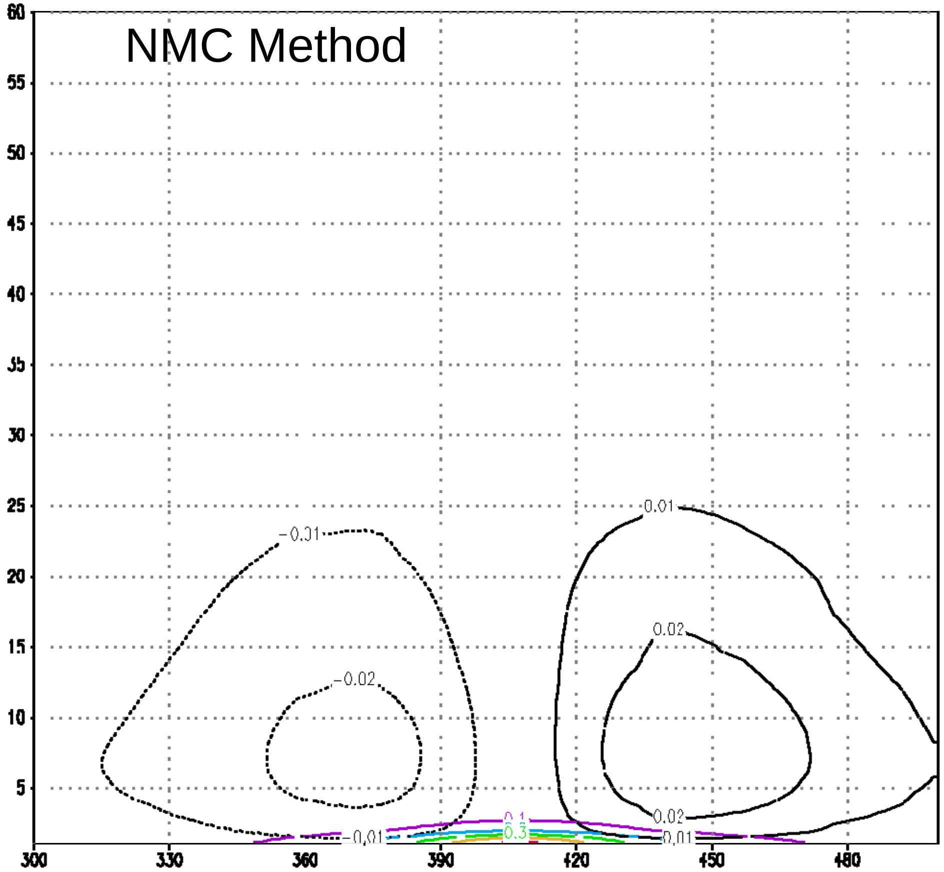
GSI – Based on NMM Fcst Errors Using NMC versus Monte Carlo Methods

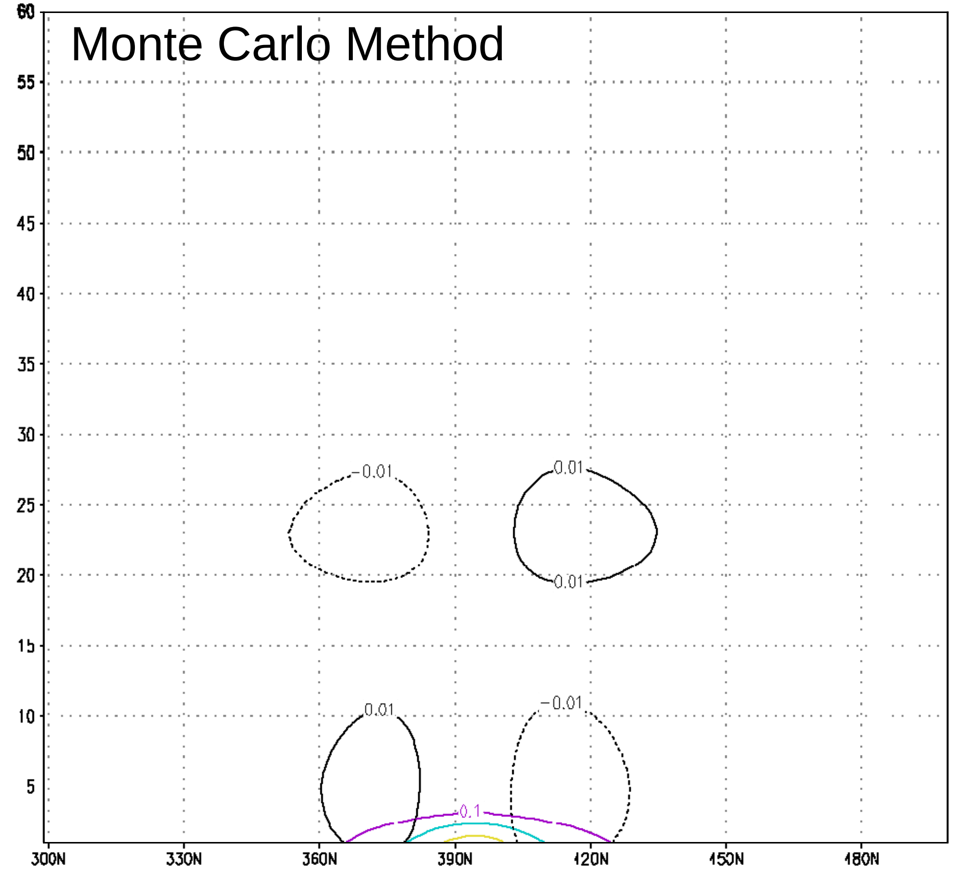




Vertical section of U increments (color contours) and corresponding T increments (black contours) of a wind ob with 1 m/s innovation at N45 and 250 mb.

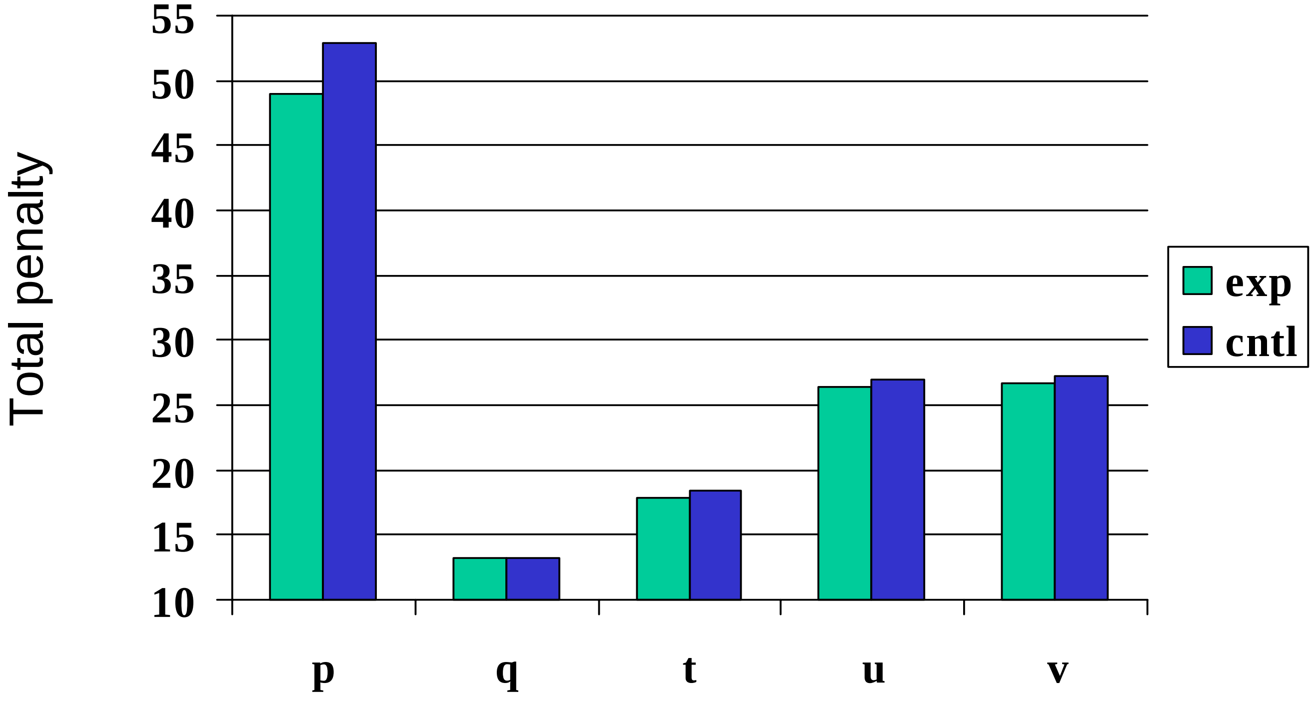
GSI – Based on NMM Fcst Errors Using NMC versus Monte Carlo Methods





Vertical section of T increments (color contours) and corresponding U increments (black contours) of a T ob with 1 degree innovation at N45 and 1000 mb.

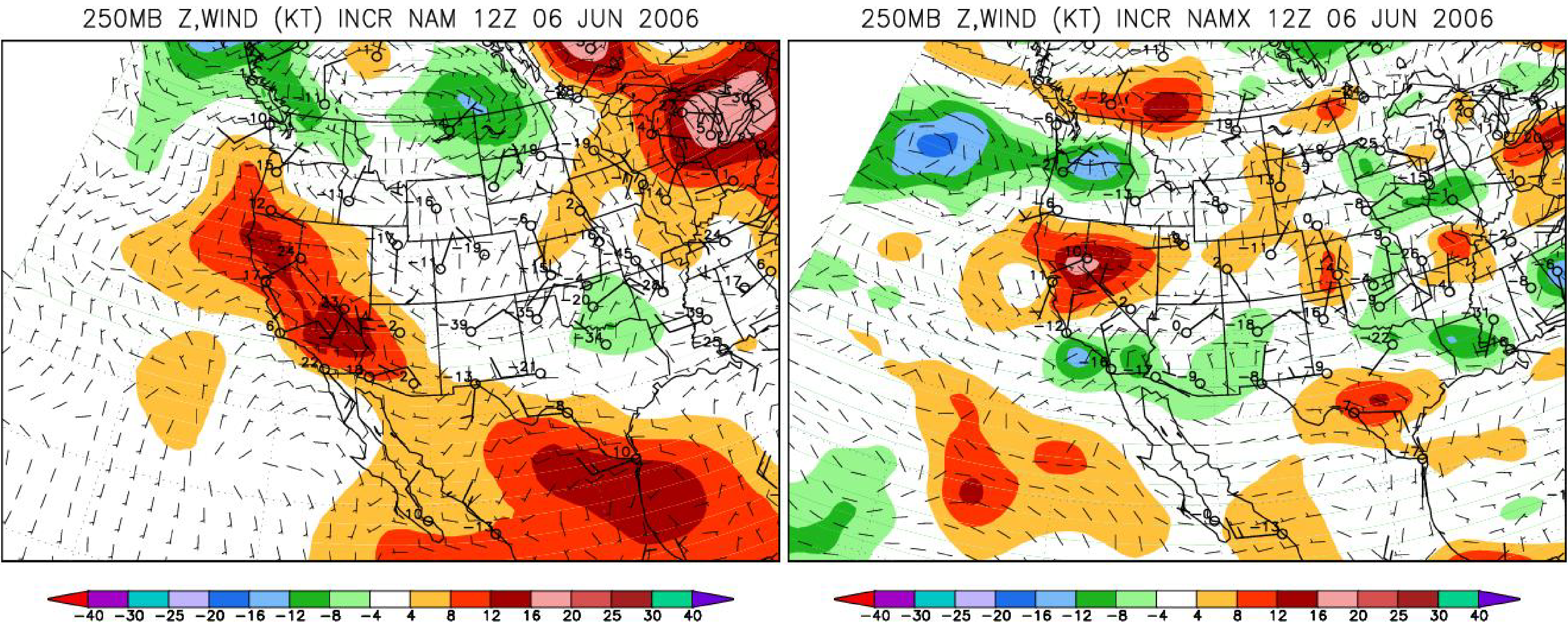
Forecast impact of B (Monte Carlo)



First guess fit to conventional data at end of each 12-hour cycle averaged over 16 cases

250 mb Analysis Comparison

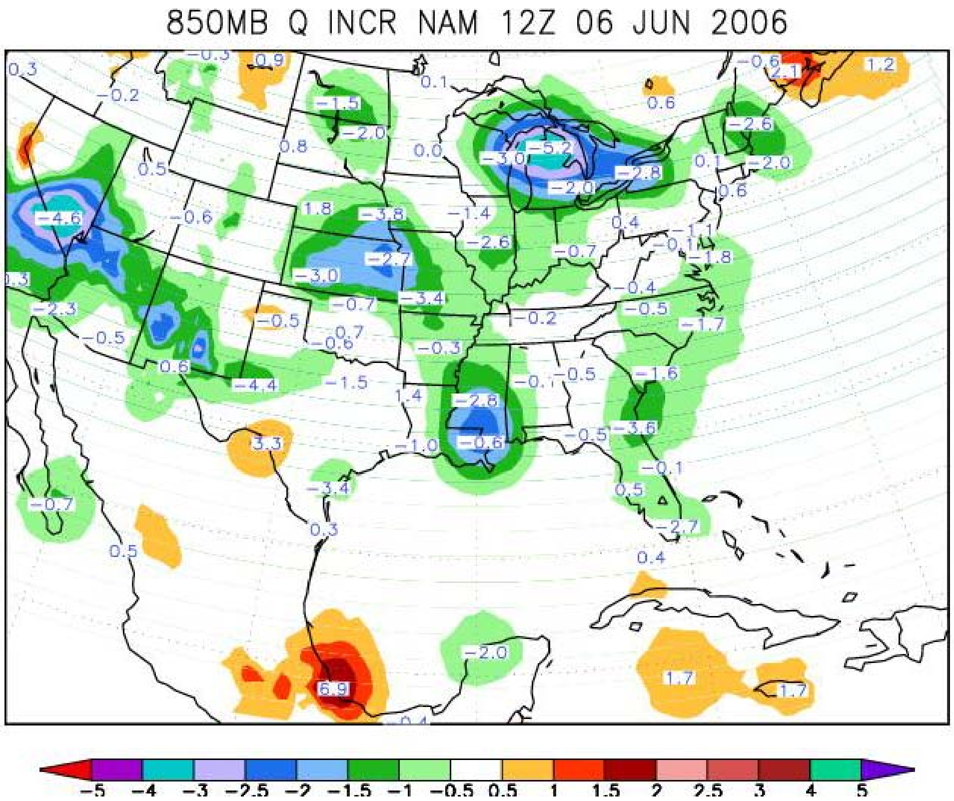
http://wwwt.emc.ncep.noaa.gov/mmb/mmbpll/eta12pllincr_2mbtop/

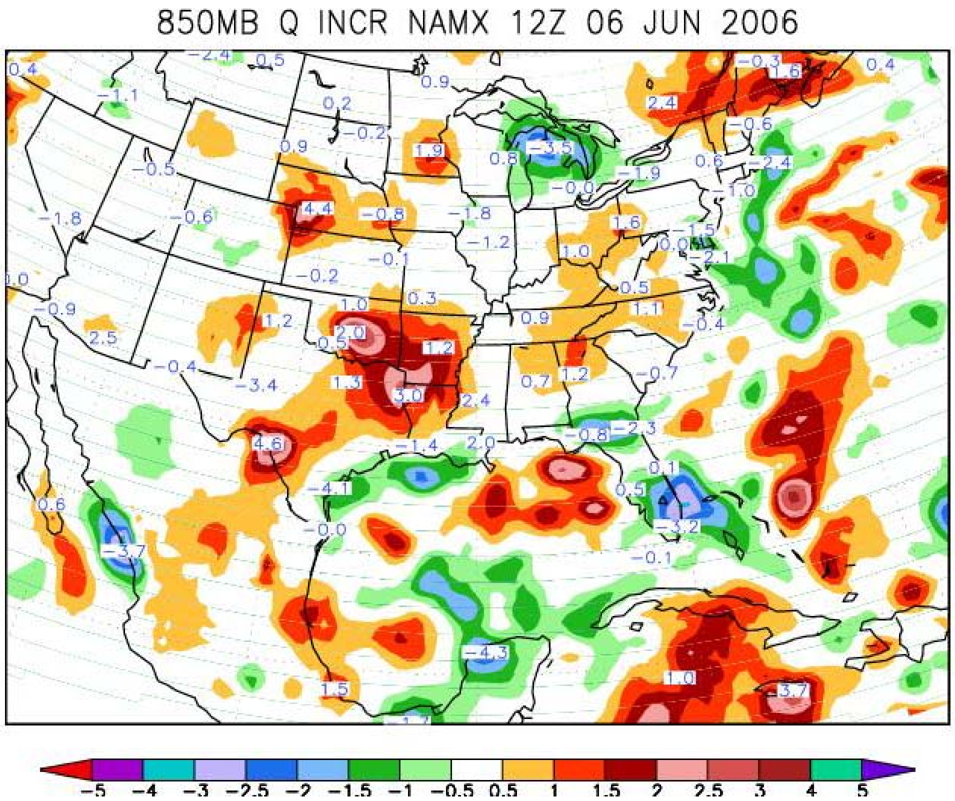


Generally smaller increments (corrections) in both magnitude and horizontal scale in NAMX versus NAM

850 mb Analysis Comparison

http://wwwt.emc.ncep.noaa.gov/mmb/mmbpll/eta12pllincr_2mbtop/

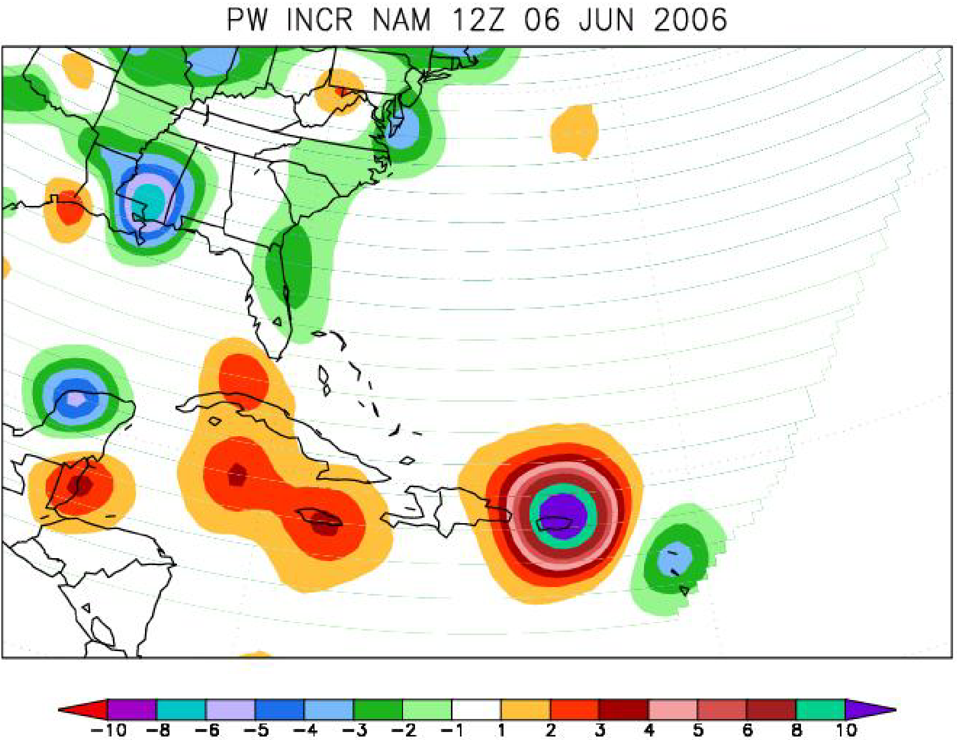


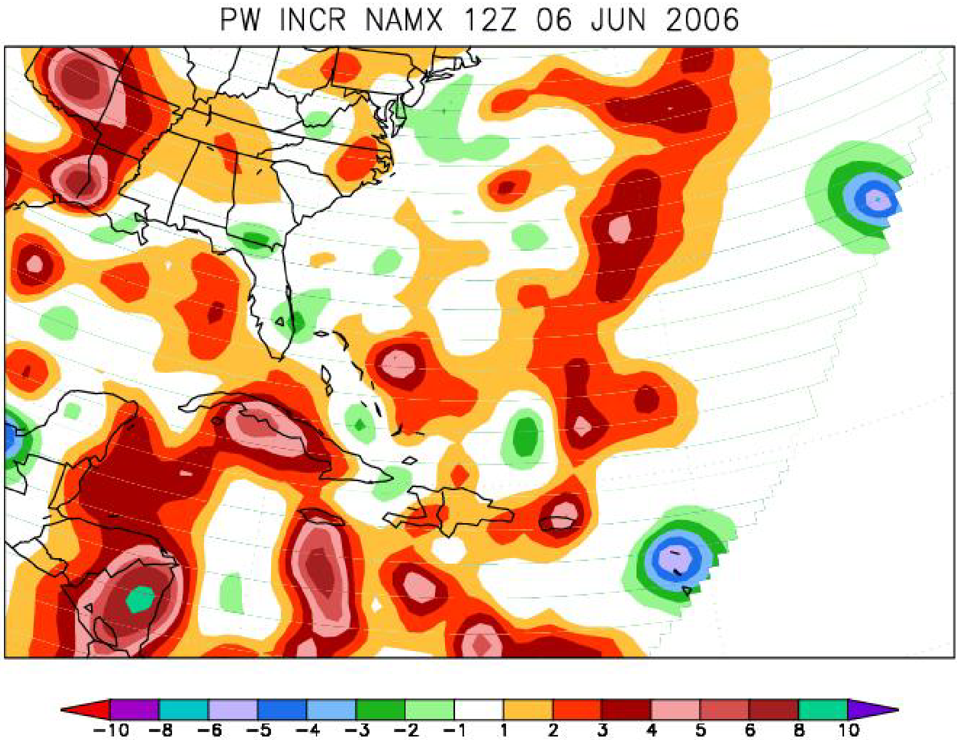


Generally smaller horizontal scale of specific humidity increments (corrections) in NAMX versus NAM with increments much larger in magnitude and much more extensive over oceans

TPW Analysis Comparison

http://wwwt.emc.ncep.noaa.gov/mmb/mmbpll/eta12pllincr_2mbtop/





Generally smaller magnitude and horizontal scale of total column precipitable water increments (corrections) in NAMX versus NAM with increments much larger magnitude and more extensive over oceans

Precipitation Assimilation

Feature	OPNL NAM	WRF NMM
Hourly merged Stage II/IV precipitation analysis	1) Used as driver for model soil moisture 2) If $P_{obs} < P_{mod}$, nudge model precip,hydrometeor, T and q fields	Use as driver for model soil moisture No nudging yet in WRF
GOES cloud top data	Used to nudge model cloud and moisture fields	No nudging yet in WRF Future use: adjust model cloud and moisture fields in combination with refl
3-D reflectivity data	Not used	Not used Future use: adjust model's moisture and hydrometeor fields

Pre-processing & Bias Correction of Precipitation Analysis Input to LSM

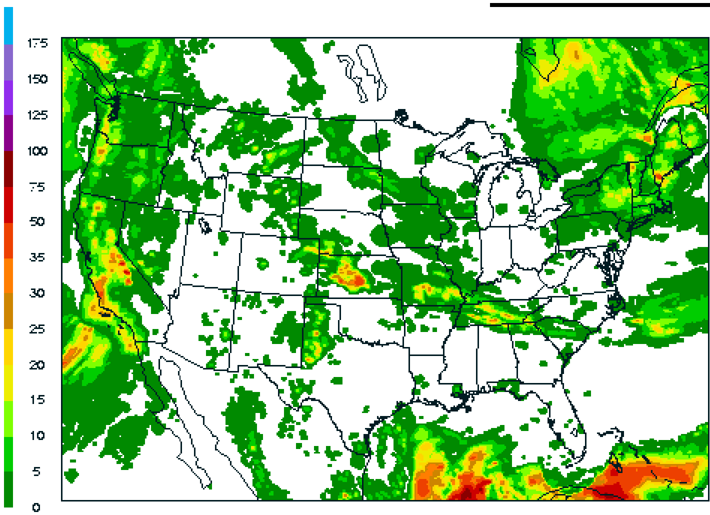
- **Merging of Stage II/IV – no change with WRF**
  - The more timely Stage II (created directly from hourly radar and gauge data) is used to supplement the Stage IV (regional analyses from the RFCs, some QC, mosaicked for national coverage)

Long-term budget adjustment – has been spun-up from WRF-NAM parallel data assimilation

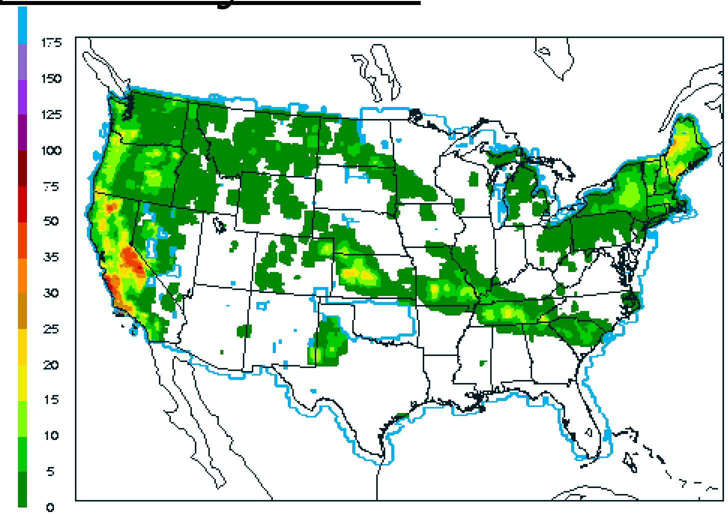
  - CPC daily gauge analysis is used in correcting for biases in Stage II/IV. A long-term 2-D precip surplus/deficit (hourly *vs.* the more accurate daily) array is kept and used to make adjustment to hourly precip input (up to +/- 20% of original hourly values)

Budget Adjustment (bias correction) for Input Precip

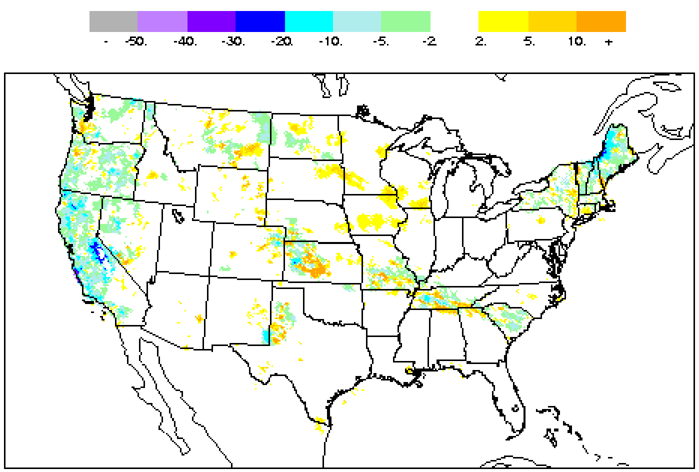
24h ending 22 May 2006



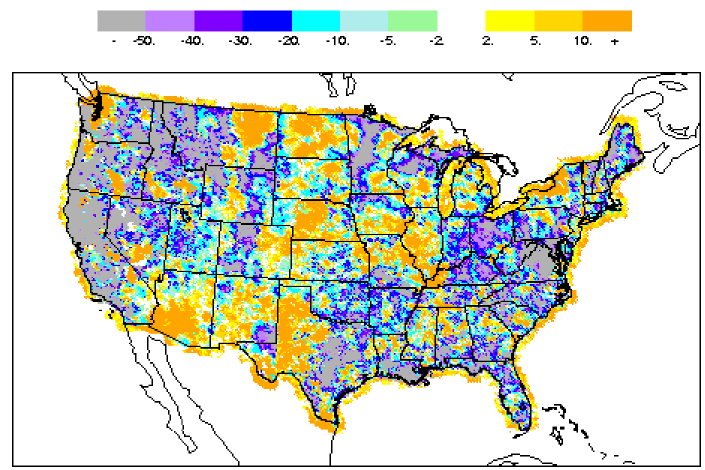
Precip fed into soil



Verifying daily precip analysis



24h precip deficit/surplus



Cumulative precip deficit/surplus, used to adjust future hourly input

NAM-MOS

- Application of current MOS (derived from Eta forecasts) to WRF-NAM produced degraded quality (see upcoming NWS TIN)
- Late discovery of this fact led Alaska Region to request more time to transition to GFS MOS
- NCEP to run an interim Eta-32
  - In Fire Weather / IMET Support runslot
    - NAM-MOS will have same availability as today
    - for no-more-than 6 months since FWIS reinstated in FY2007
  - Using SREF 32 km control member code
  - Initialized off NAM analysis (WRF-GSI)
  - Same lateral boundary conditions as NAM (off-time GFS)
  - MOS only product to be distributed

Operational NCEP Precip Type Algorithm

Based on Baldwin and Contorno (1994)

- Examines a vertical thermodynamic structure that a falling hydrometeor encounters as it falls to the ground
  - First determines if precip is generated as water, supercooled water or ice and then uses decision tree approach
- Identifies “warm” (> 0ºC) and “cold” (< 0ºC) layers
  - Computes area between 0 and Tw to identify layers
- Diagnoses snow if:
  - Coldest T at any level with p > 500 mb is ≤ -4°C

  AND

  - Area between Tw and –4°C < 3000 deg m
- Diagnoses freezing rain if:
  - Coldest T in saturated layer is > -4°C and Tsfc < 0°C

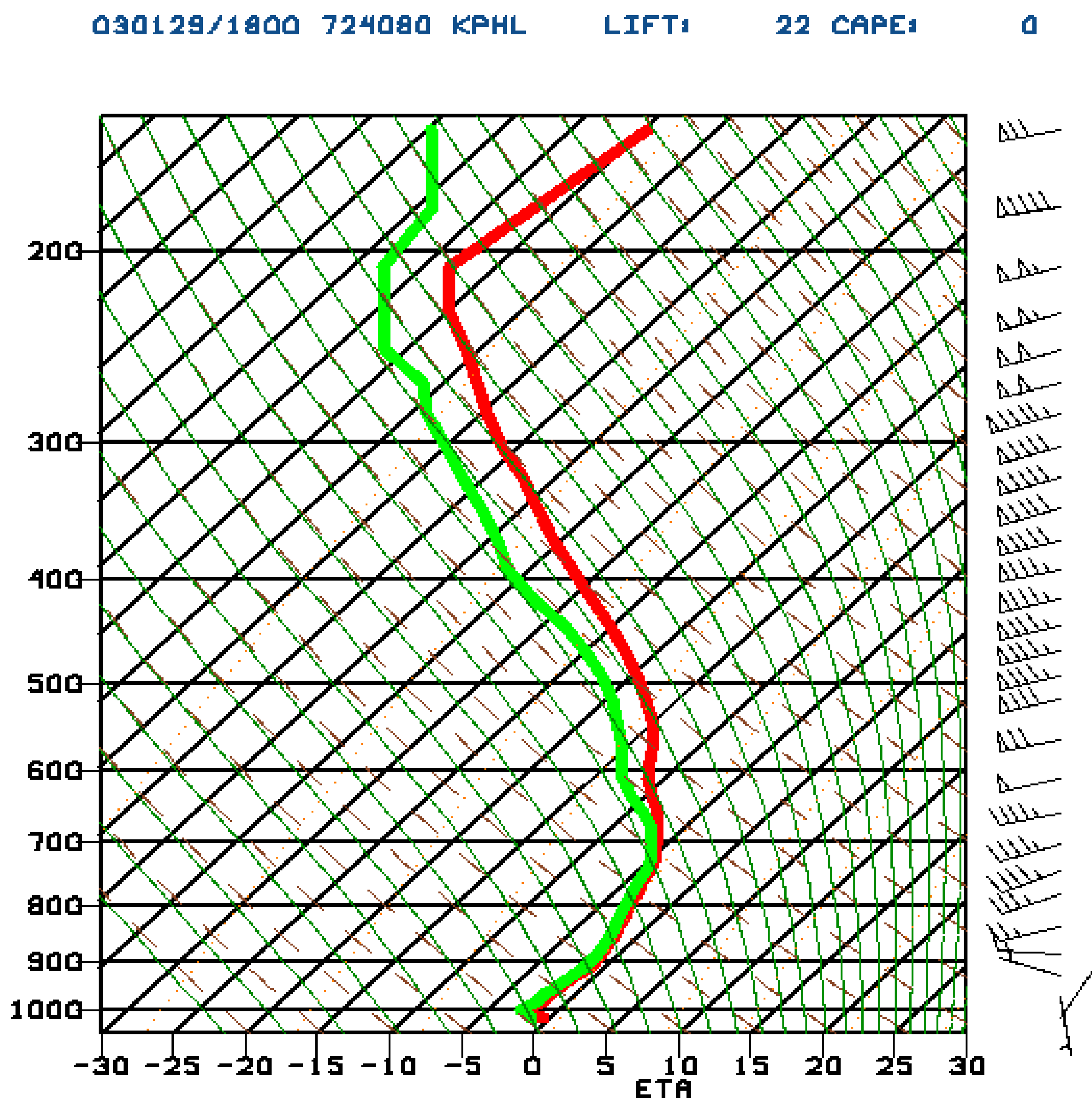
  OR

  - Area between –4°C and Tw > 3000 deg m

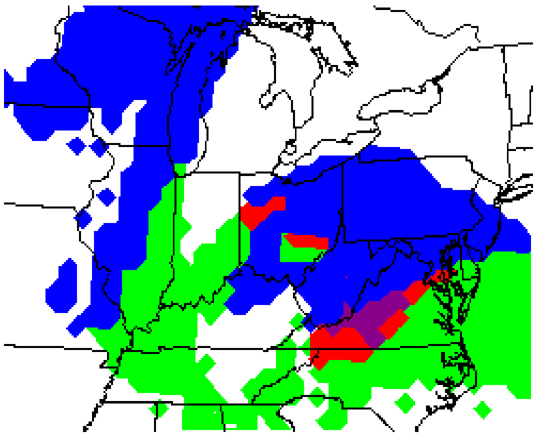
Significant Issue with this NCEP p-type scheme

it intentionally over-predicts ZR / IP to have high POD

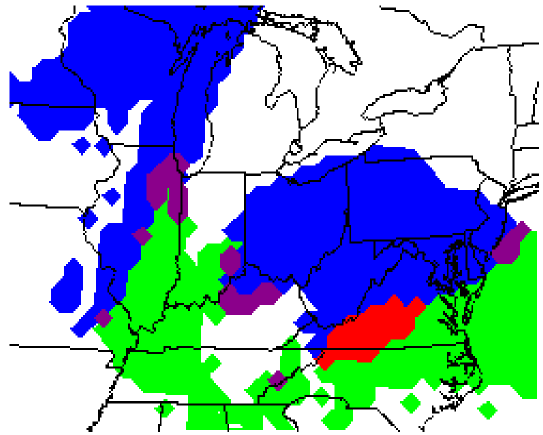
- area check based on -4°C
- area in this sounding between Tw and –4°C is > 3000
- The algorithm would predict ZR for this sounding



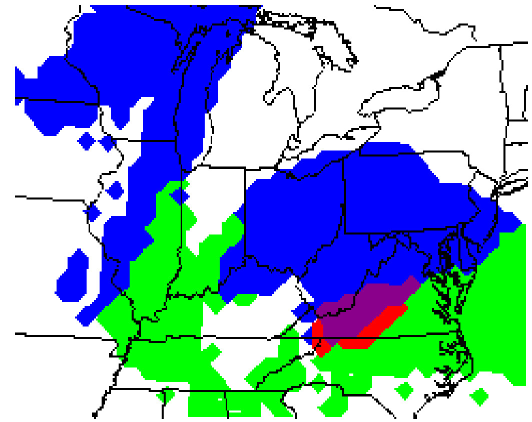
Run Multiple Algorithms on Single Thermodynamic Profile



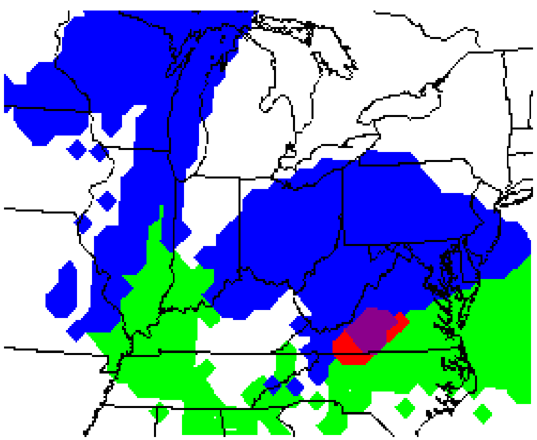
150228/1500V054 54-HR NCEP PRECIP TYP



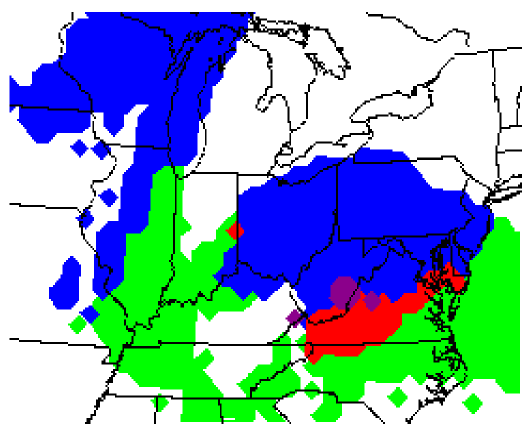
54-HR RAMER TYPE



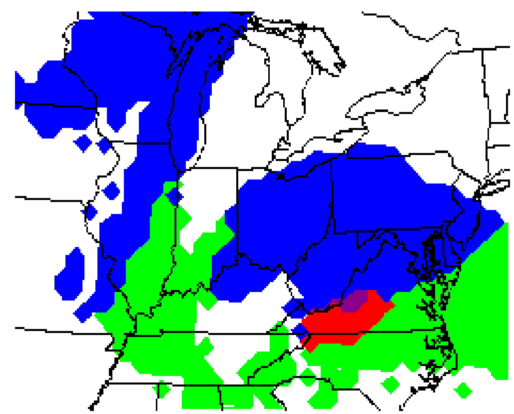
54-HR BOURGOUIN TYPE



54-HR REVISED NCEP TYPE



54-HR EXPLICIT NCEP TYPE



54-HR DOMINANT PRECIP TYPE

Summary of Procedure to Compute Dominant Precip Type

5 precip-type algorithms are run at every gridpoint with measurable precip

1. NCEP
2. Revised NCEP (area check based on 0°C)
3. Ramer
4. Bourgouin
5. Explicit based on model snow ratio/rime factor

Each scheme gives an "answer" at each point, and the 5 answers are tallied with the most common type "winning" for that point at that time

Ties broken in favor of severity (ZR>SN>IP>RA)

Pre-Implementation Issues

Issue	Consequence
WRF-CMI complexity, late arrival of computer (1/05) and late freezing of the Eta (5/05)	Delay from September 2005 to March 2006
Initial issues with WRF runtime (fixed by EMC, IBM and NCAR)	Sacrifice 10 km target resolution
Discovery of glitch in final Eta version (5/05) in December 2005	Time only to tune NMM physics to closely reproduce Eta
Saturated computer 10/05 – 5/06	Only one full-resolution parallel, retrospective parallel at lower res and smaller domain
All of the above and desire to have sufficient time for field evaluation period	Delay from March 2006 to June 2006

WRF-NMM/GSI Testing

- Parallel testing for NAM began in Summer 2005
- Parallel change log for the test system with fully cycled land states, use of observed precip in land-sfc and 2mb model top pressure began 10/27/2005:

http://wwwt.emc.ncep.noaa.gov/mmb/mmbpll/paralog/parachl.namx.wrfnmm_fullcyc_2mbto

When	Who	What
2006/05/25/18	Parrish, Wu	• Begin assimilation of NEXRAD Level 2 radial wind data in the GSI analysis
2006/05/22/18	Derber, Parrish, Wu	• Changes to GSI analysis: 1. Turn off assimilation of surface temperature data over land in the GSI analysis 2. Turn off MSU satellite data 3. Tighten the gross error checks for all conventional data except winds. 4. Increase iteration number from 50 -> 75 5. +/- 15 minute window for all surface obs (was +/- 1.5 hours) 6. Begin assimilation of NEXRAD Level 2.5 radial wind data in the GSI analysis 7. The amplitude part of the background error was retuned to improve treatment of winds (reduced penalty function) • Cycled NDASX was restarted from the NDASY cycle
2006/05/18/18	Ferrier, Janjic, Pyle, Black	• Use vegetation component of z0base instead of z0 the calculation of the Zilitinkevitch fix for z0T in module_sf_myjsfc.F. • Include vertical variation of atmospheric density in computation of turbulent mixing of temperature, moisture, wind, and total condensate.
2006/04/20/18	Lin, Rogers, Wu	• Implement set of changes from NAMY parallel: 1. Changed the computation of the difference between the 24h sum (12Z-12Z) of edas precip input and the daily gauge analysis in the pcpbudget code to inflate the daily gauge analysis data by 10% to account for under-catch of precip before the difference is computed. Previous version of the code for the WRF-NMM NDASX had no inflation of the analysed daily gauge data, while the ops NDAS has a 10% inflation. 2. Revert back to pre-3/17 vertical background errors for humidity in the GSI analysis. 3. Begin use of GPS-IPW data in GSI analysis • Cycled NDASX on white restarted from NDASY cycle on blue

Real-Time Monitoring Webpage

http://www.emc.ncep.noaa.gov/mmb/mmbpll/nampll12_fullcyc_2mbtop/

- **Soil/Surface Parameters**
- **Sea Level Pressure**
- **Total Precipitation**
- **Total Convective Precipitation**
- **Precipitation Type**
- **Visibility**
- **% Frozen Precip vs Precip Type**
- **% Frozen Precip vs Precip Rate**
- **Precip Rate**
- **Convective Precip Rate**
- **Total Precip and Convective Precip Rate**
- **% Frozen Precip vs Precip Type vs Lowest Level Rime Fctr**
- **Total Column-Integrated Cloud Water + Rain**
- **Total Column-Integrated Cloud Ice + Snow**
- **Total Column-Integrated Condensate**
- **NAMX Total Column-Integrated Supercooled water and melting ice**
- **NAMX Base and Top height of supercooled liquid water layer**
- **Rime Factor vs snow/rain/cloud water/cloud ice**
- **850 mb Height/Temps**
- **850 mb Winds**
- **700 mb Temperature**
- **700 mb Height and Precip Water**
- **700 mb RH, Omega**
- **500 mb Heights**
- **250 mb Heights/Wind Speed**
- **250 mb Winds**
- **250 mb Temps**
- **300 mb Temps**
- **50 mb Temps**
- **5 mb Temps**
- **Cloud Fractions**
- **Cloud Top Temps/Height/Pressure**
- **Cloud Base Height/Pressure**
- **Ceiling Height**
- **Deep Convective Cloud Top/Bottom Pressure**
- **Total Convective Cloud Top/Bottom Pressure**
- **Grid-Scale Cloud Top/Bottom Pressure**
- **Height of Lowest Freezing Level**
- **PBL Height**
- **2-m Temp**
- **Skin Temp**
- **Lowest Model Layer Temp**
- **Snow H2O Equivalent**
- **0-10 cm Soil Temp/Moisture**
- **10-40 cm Soil Temp/Moisture**
- **0-100 cm Soil Moisture Availability**
- **Skin temp - 1st layer soil temp**
- **Skin temp - Lowest Model layer temp**
- **2-m temp - skin temp**
- **Lowest Boundary Layer Td**
- **2-m Dew Point Temp**
- **Best CAPE, CIN, LI**
- **Mixed Layer CAPE, CIN**
- **Sfc Downward SW Flux**
- **Sfc Upward SW Flux**
- **Sfc Downward LW Flux**
- **Sfc Upward LW Flux**
- **Instantaneous Albedo**
- **Sfc clear sky - downward SW flux**
- **Net Sfc SW flux**
- **Net Sfc LW flux**
- **Net Sfc SW+LW flux**
- **Ground Heat flux**
- **Latent Heat flux**
- **Sensible Heat flux**
- **Surface Energy Residual**
- **Potential Evaporation**
- **Surface Exchange Coefficient**
- **Lowest Model Layer Q2**
- **2nd Lowest Model Layer Q2**
- **Surface Friction Velocity**
- **Surface Drag Coefficient**
- **Simulated Radar Reflectivity**
- **TOA Brightness Temperatures**
- **CONUS 10-m winds (by region)**
- **CONUS lowest Model layer winds (by region)**
- **Regional 10-m winds**

Real-Time Parallel Stats

http://wwwt.emc.ncep.noaa.gov/mmb/mmbpll/pll12stats.nmmx_01jan06-23may06/

1. PRECIPITATION THREAT AND BIAS SCORES

CONUS, 24-84 hour forecasts	Eastern US, 24-84 hour forecasts	Western US, 24-84 hour forecasts
Eta-12 parallel	Eta-12 parallel	Eta-12 parallel

CONUS, 24-h forecasts	CONUS, 36-h forecasts	CONUS, 48-h forecasts	CONUS, 60-h forecasts	CONUS, 84-h forecasts
Eta-12 parallel	Eta-12 parallel	Eta-12 parallel	Eta-12 parallel	Eta-12 parallel
Eastern U.S., 24-h forecasts	**Eastern U.S., 36-h forecasts**	**Eastern U.S., 48-h forecasts**	**Eastern U.S., 60-h forecasts**	**Eastern U.S., 84-h forecasts**
Eta-12 parallel	Eta-12 parallel	Eta-12 parallel	Eta-12 parallel	Eta-12 parallel
Western U.S., 24-h forecasts	**Western U.S., 36-h forecasts**	**Western U.S., 48-h forecasts**	**Western U.S., 60-h forecasts**	**Western U.S., 84-h forecasts**
Eta-12 parallel	Eta-12 parallel	Eta-12 parallel	Eta-12 parallel	Eta-12 parallel

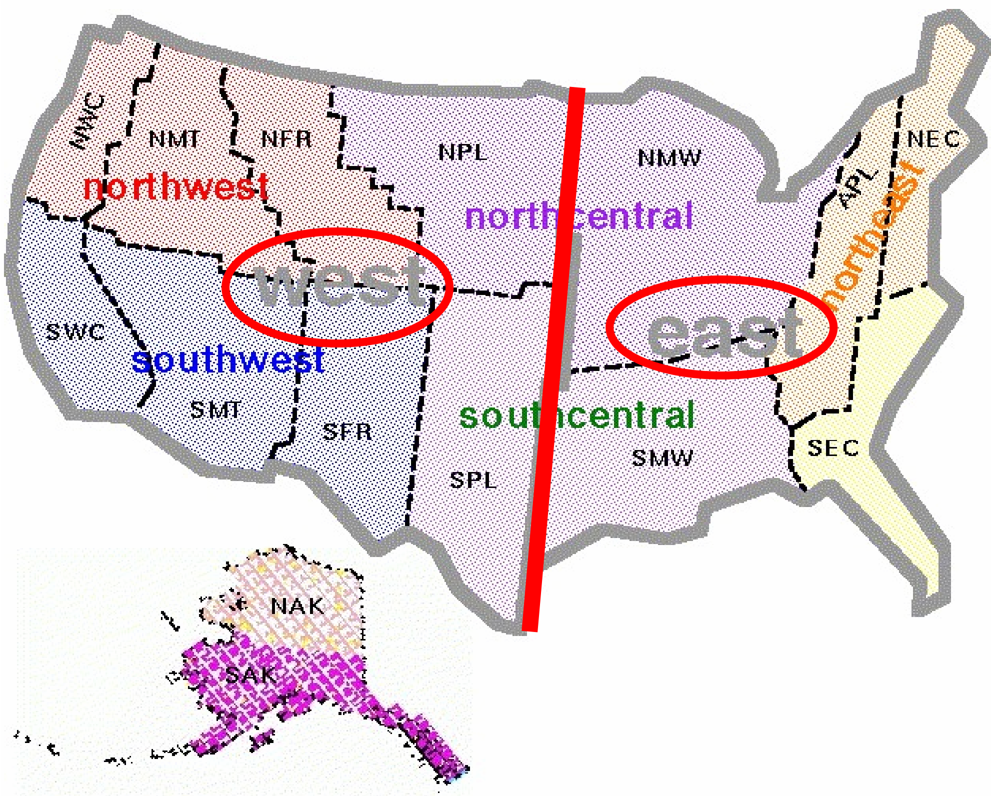
2. UPPER AIR RMS STATISTICS (12, 24, 48, 60, and 84-h forecasts)

CONUS vector wind	CONUS temperature	CONUS relative humidity	CONUS height
RMS error	RMS error	RMS error	RMS error
	Bias	Bias	Bias

Alaska vector wind	Alaska temperature	Alaska relative humidity	Alaska height
RMS error	RMS error	RMS error	RMS error
	Bias	Bias	Bias

3. NEAR-SURFACE STATISTICS

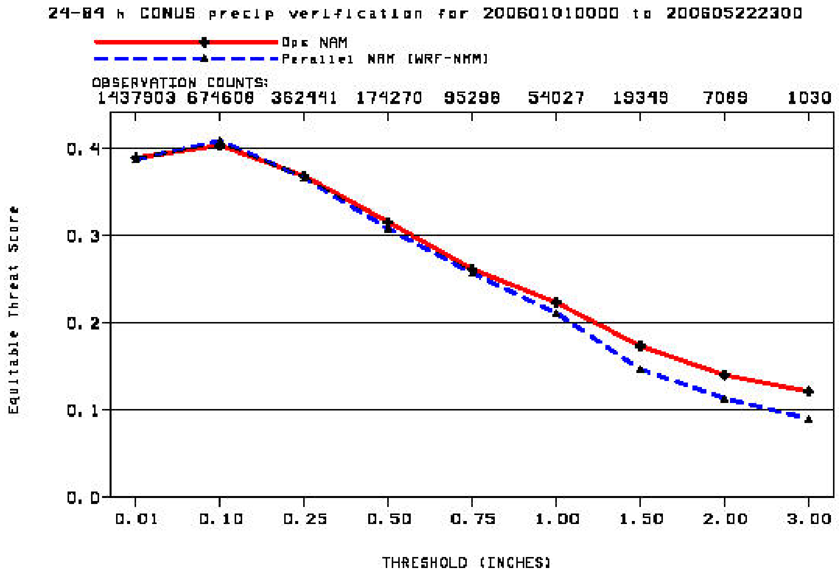
Verification Regions:

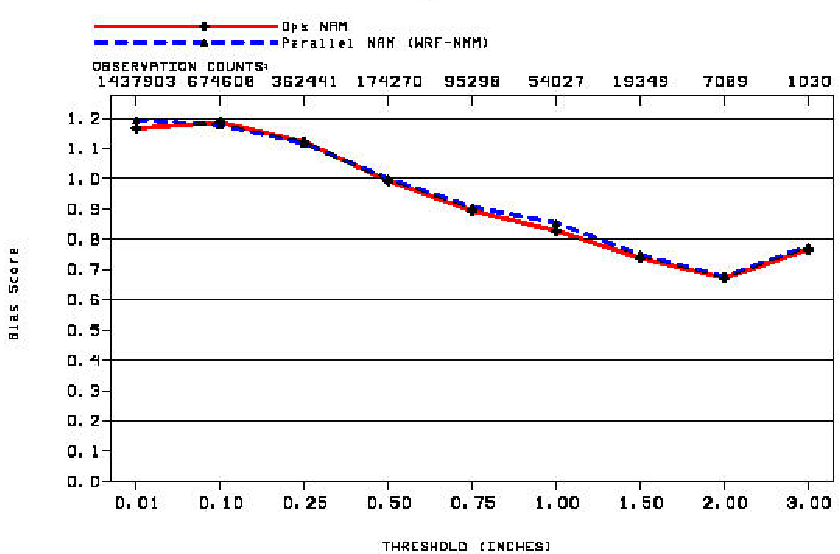


2-M Temperature 00Z CYCLE	2-M Temperature 12Z CYCLE	2-M Relative Humidity 00Z CYCLE	2-M Relative Humidity 12Z CYCLE	10-M Wind Speed (squared) 00Z CYCLE	10-M Wind Speed (squared) 12Z CYCLE
Eastern US	Eastern US	Eastern US	Eastern US	Eastern US	Eastern US
Western US	Western US	Western US	Western US	Western US	Western US
Alaska	Alaska	Alaska	Alaska	Alaska	Alaska

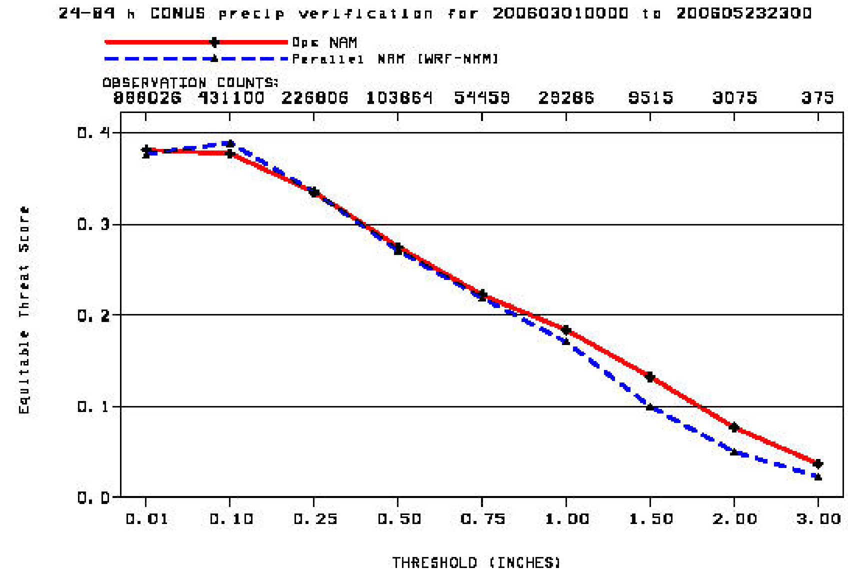
24 hr QPF Scores All Ranges

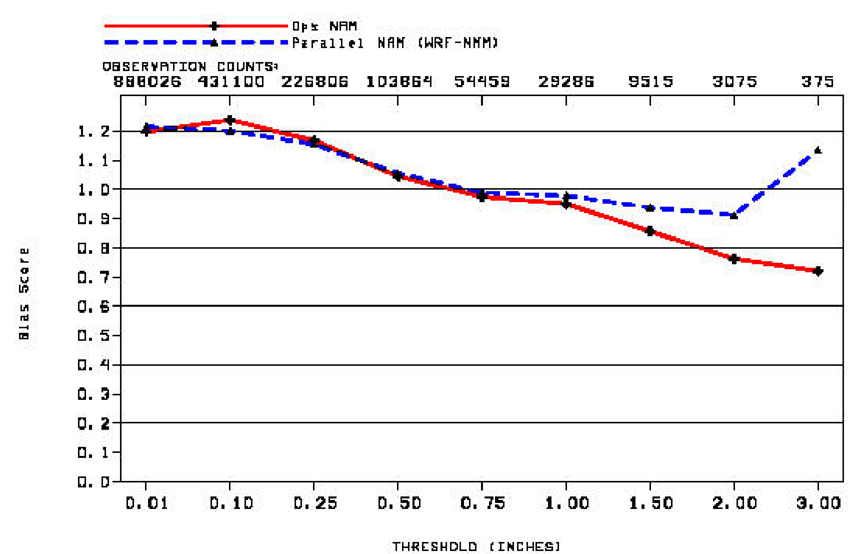
January – May 2006



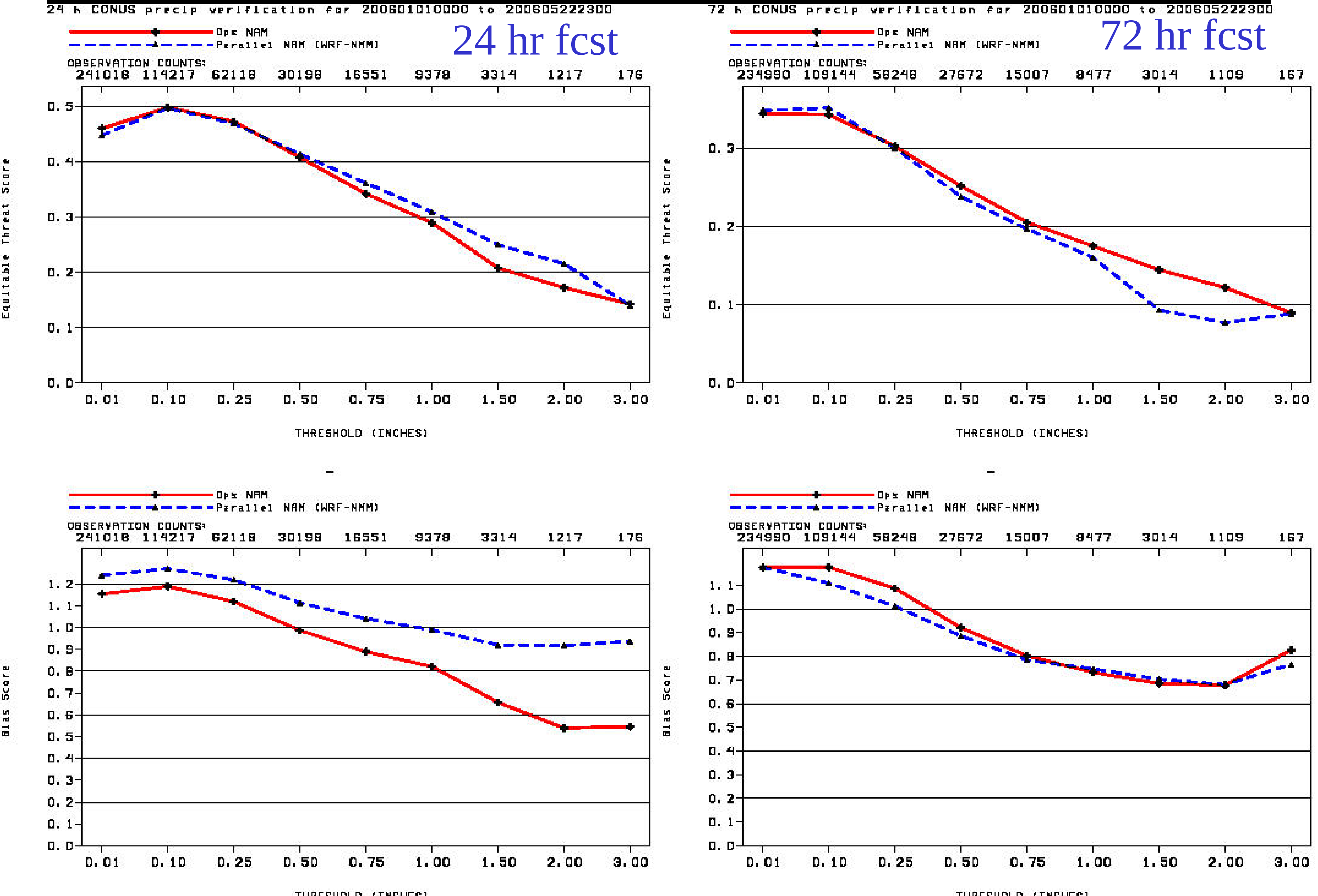


March – May 2006

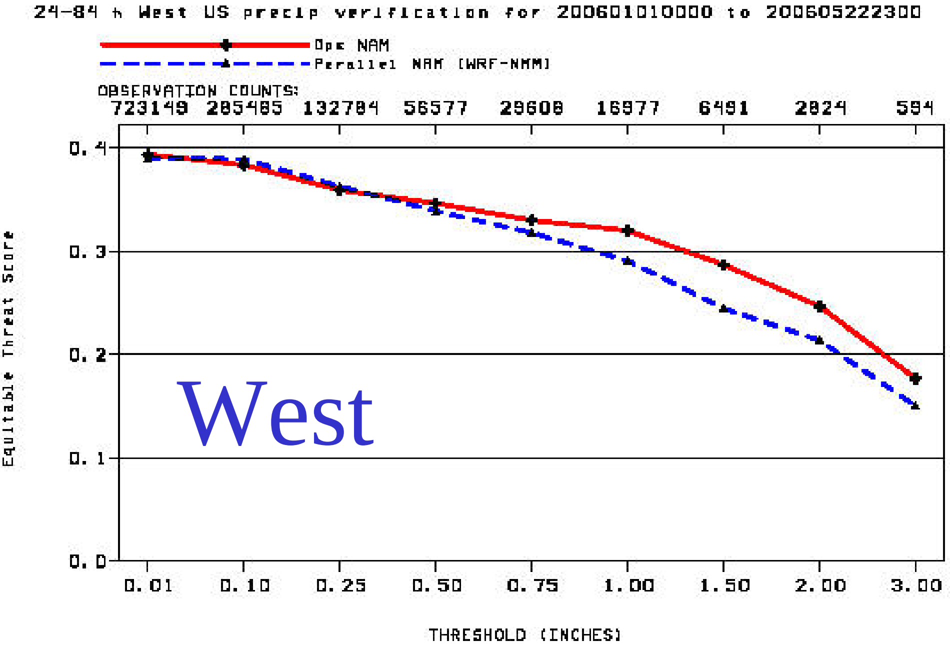


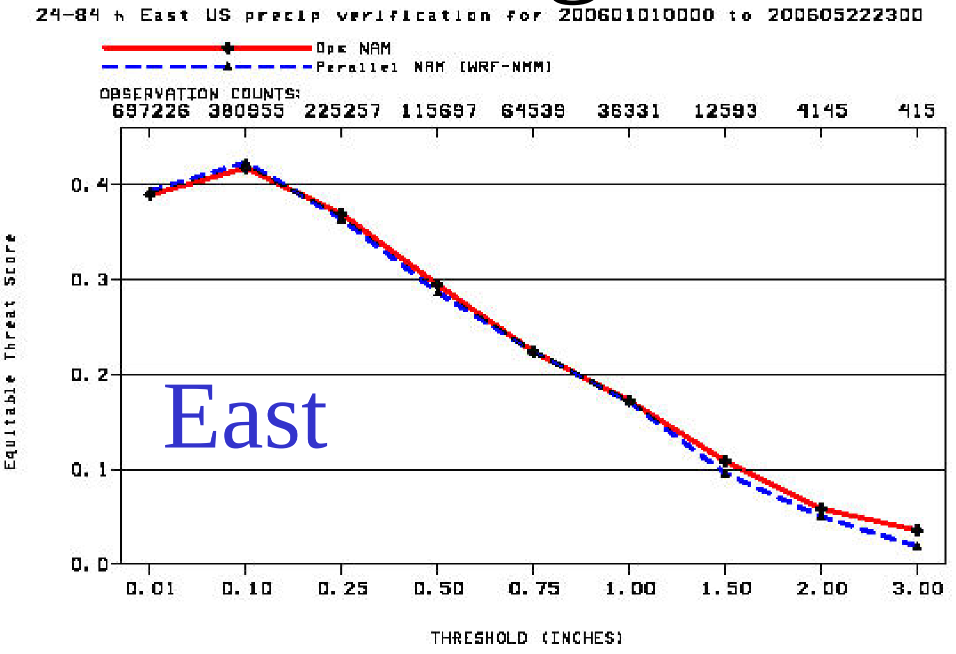


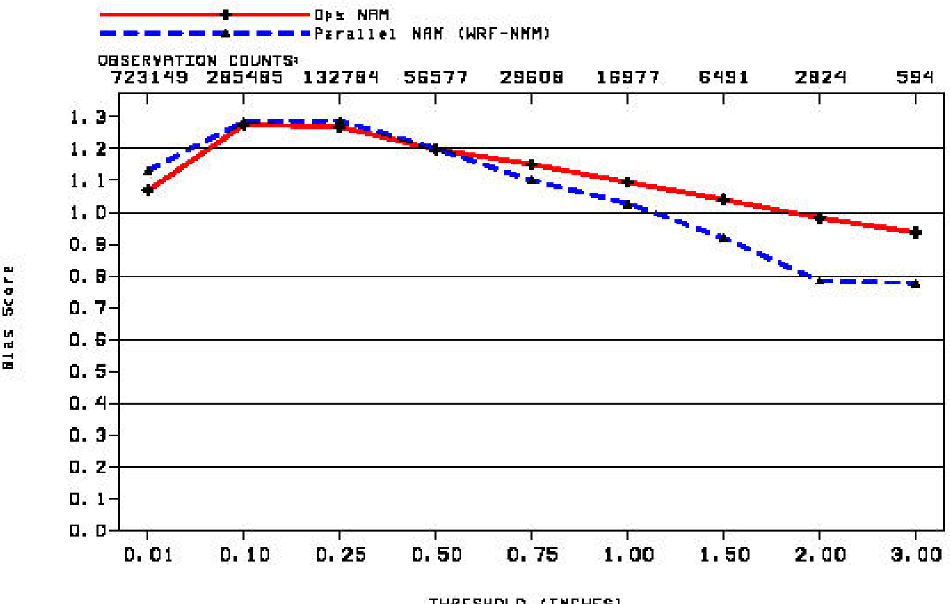
24hr+72hr ETS & Bias for 24 hr QPF

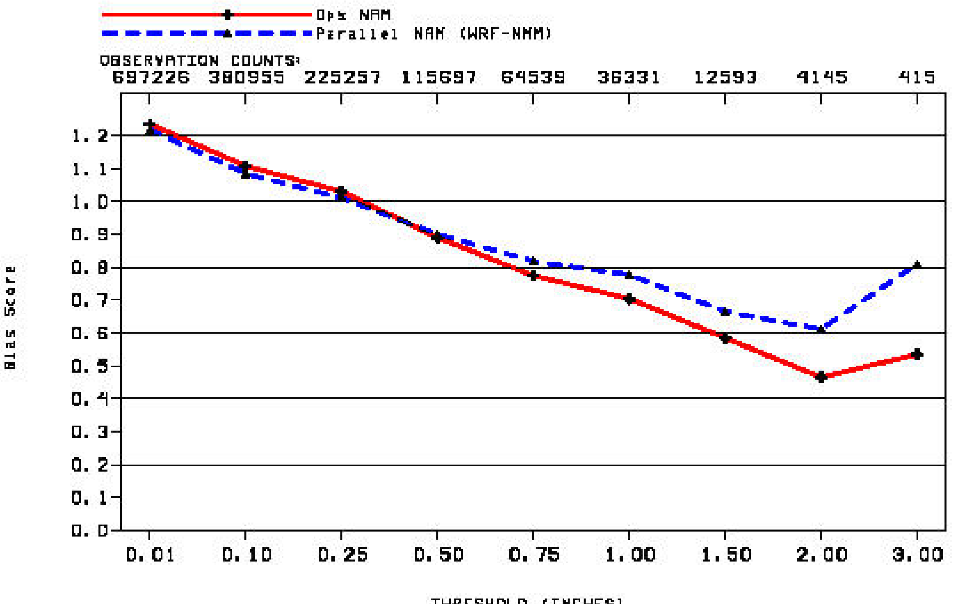


East vs West QPF All Ranges

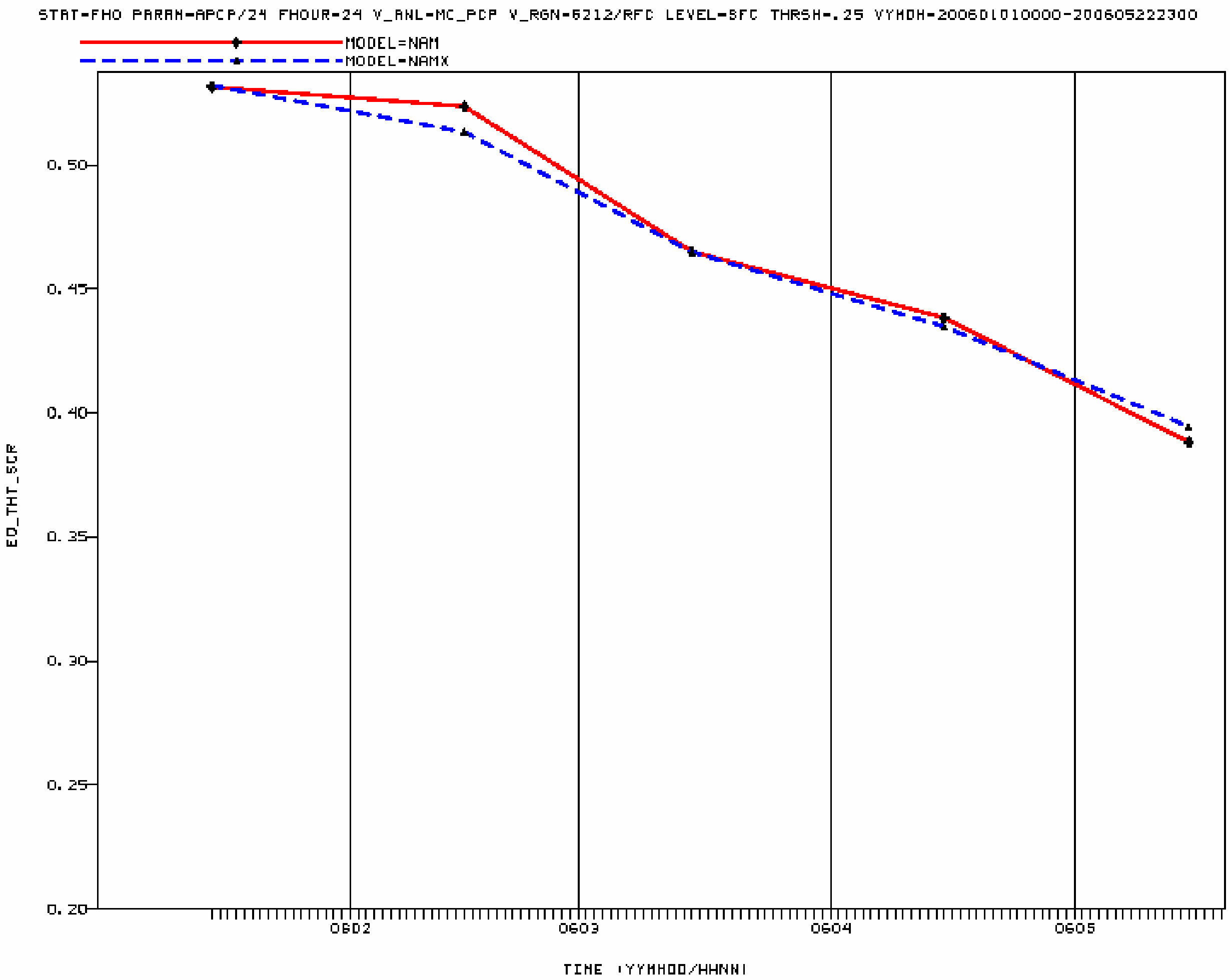








Monthly Precip Scores Time Series
NAM *vs* NAMX, 0.25”/day, Jan-May 2006



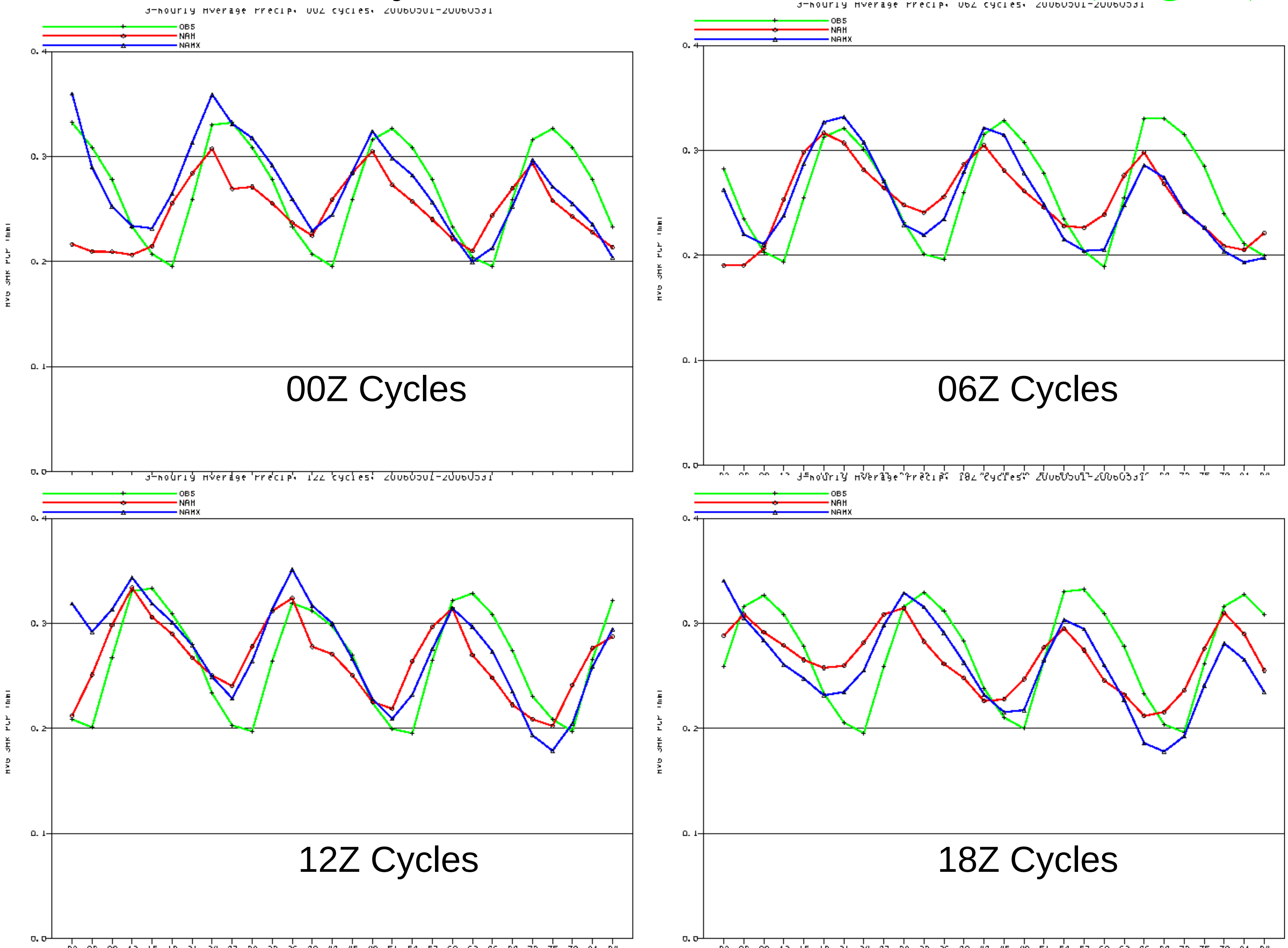
Scalar L1L2 Calculation Added to Precip Verification

In addition to *F-H-O* based precipitation scores (equitable threat, bias, POD, FAR*etc.*), precipitation verification now includes the standard scalar L1L2 components for CONUS and the 14 sub-regions.

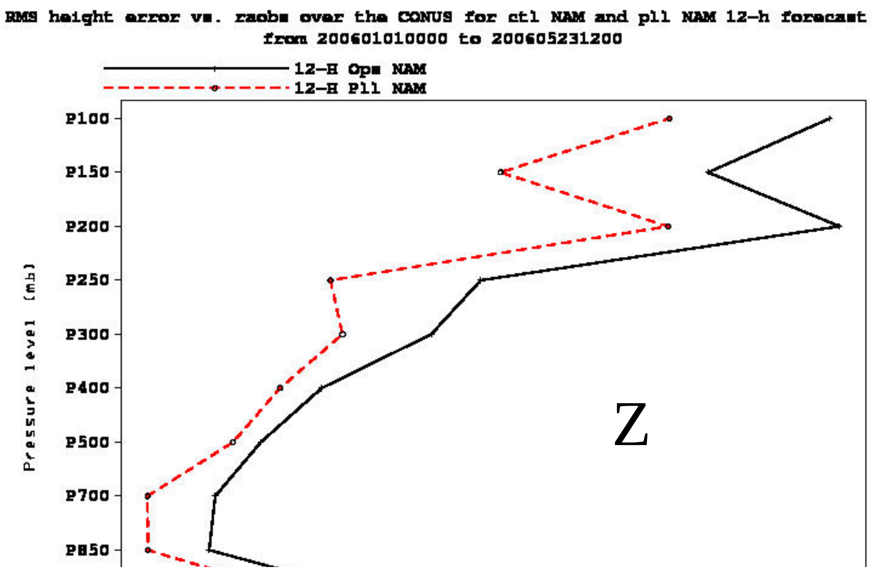
Verifications that include Grid 218 and use executable
/nfsuser/g01/meso/wx22yl/verif/exec/verfgen.x
will automatically have the precip SL1L2 in the VSDB files.

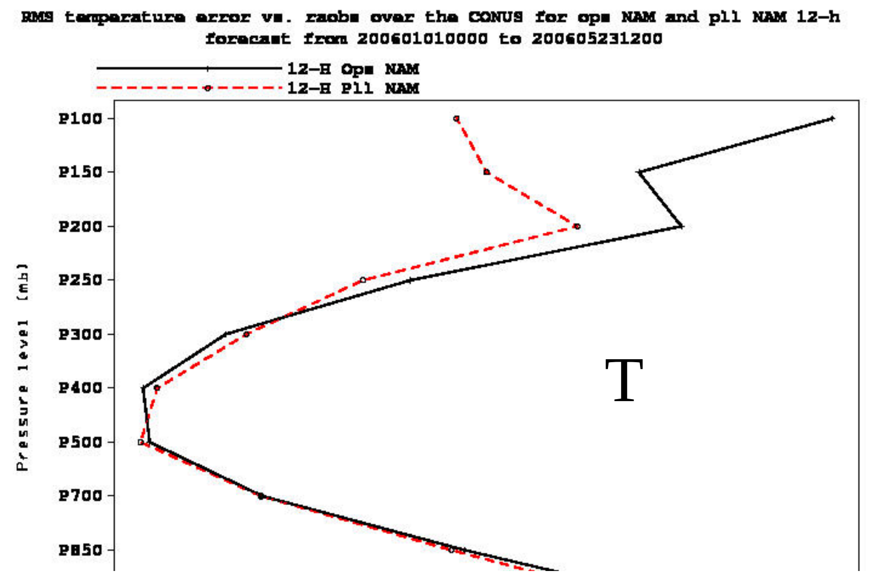
CONUS-Averaged 3-hourly Rainfall (mm)

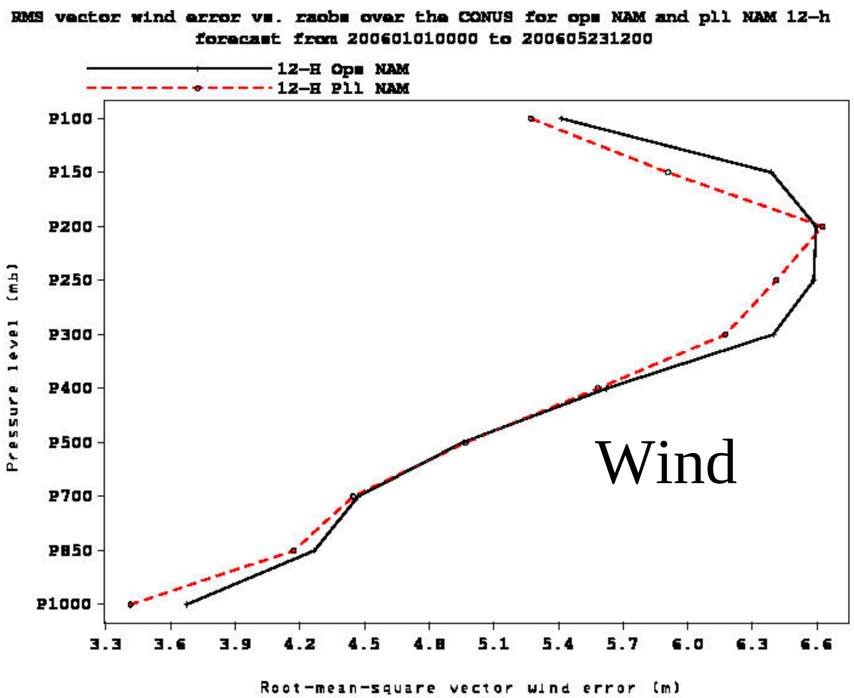
00-84h fcsts, May 2006. NAM *vs.* NAMX *vs.* OBS (Stage II)

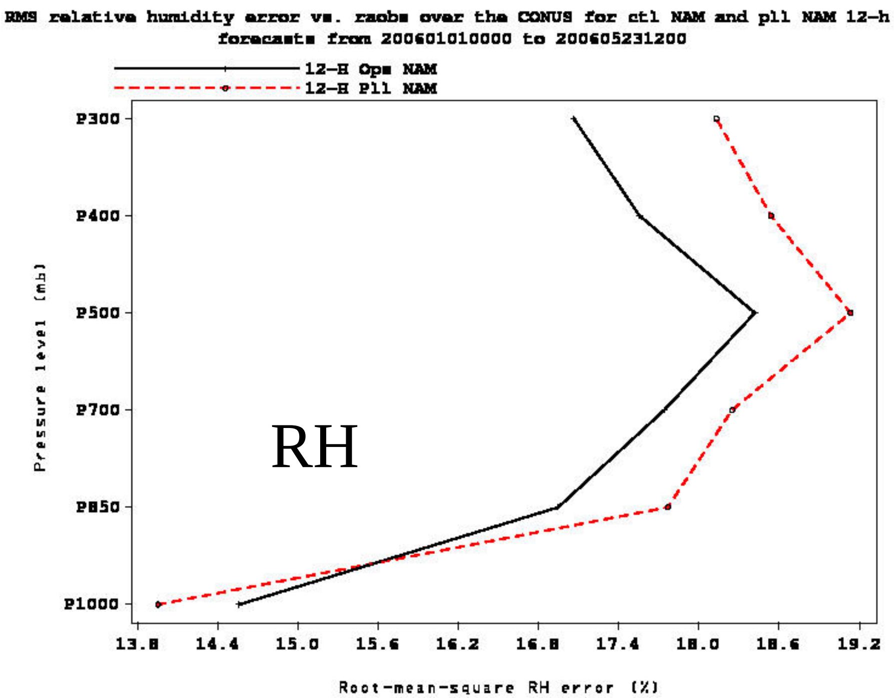


12 hr CONUS Statistics vs RAOBs

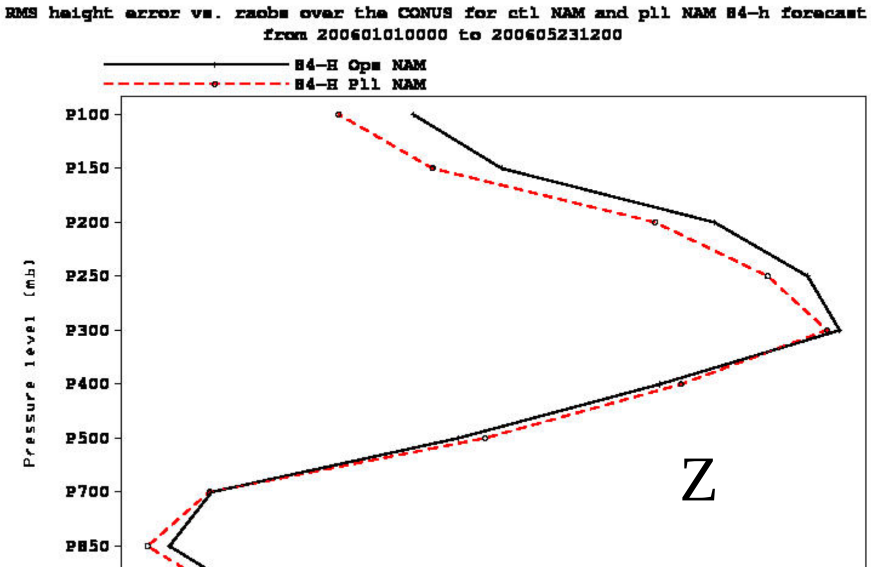


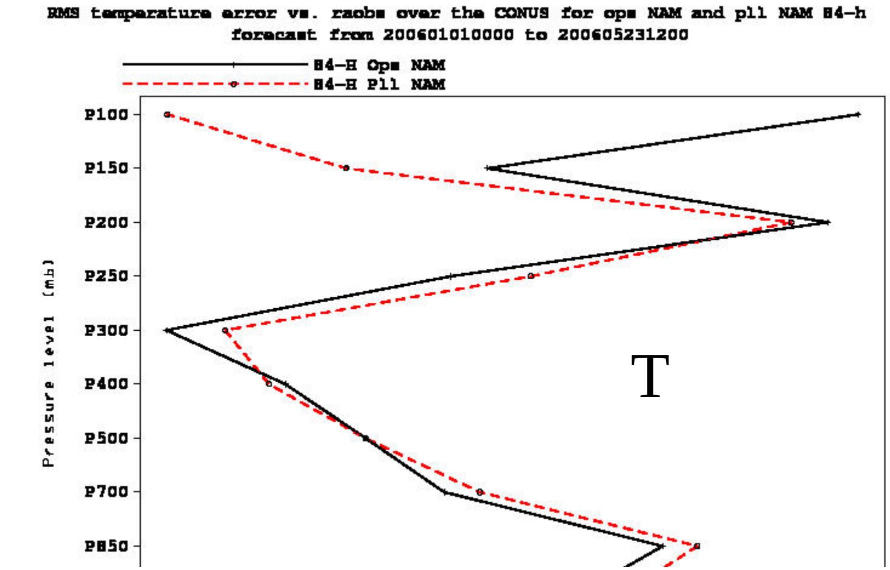


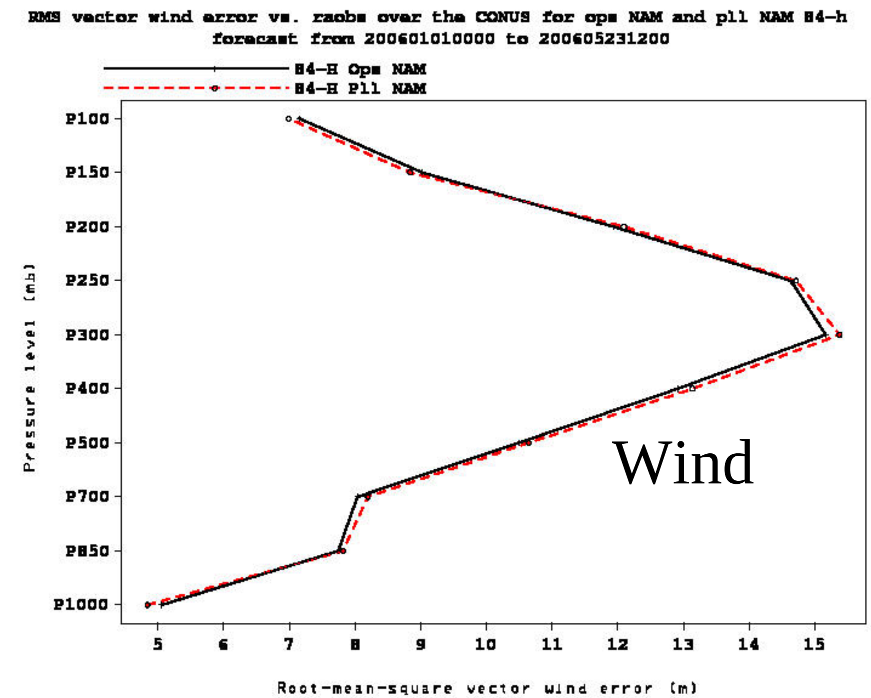


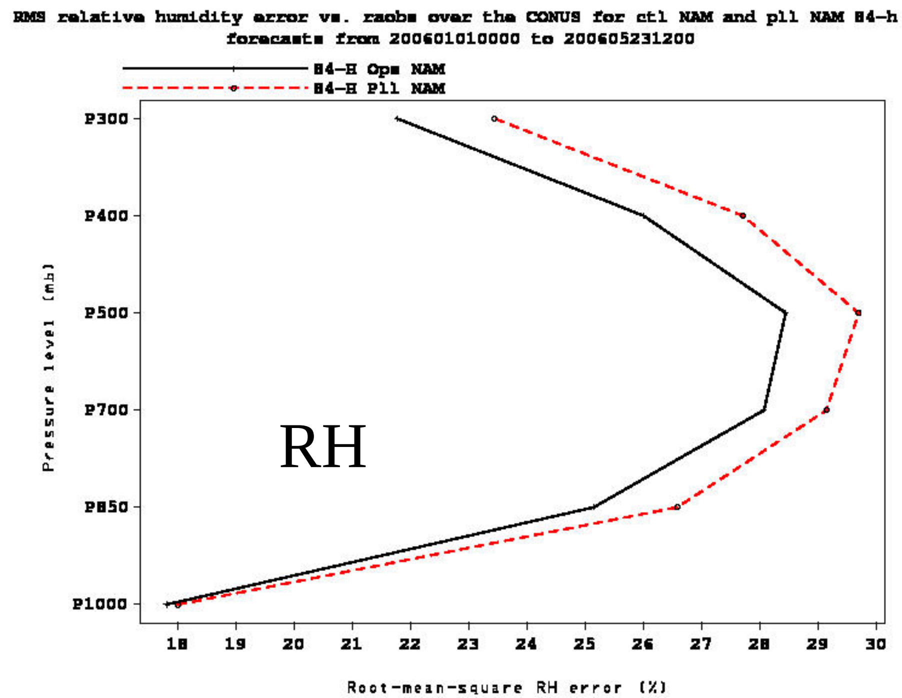


84 hr CONUS Statistics vs RAOBs

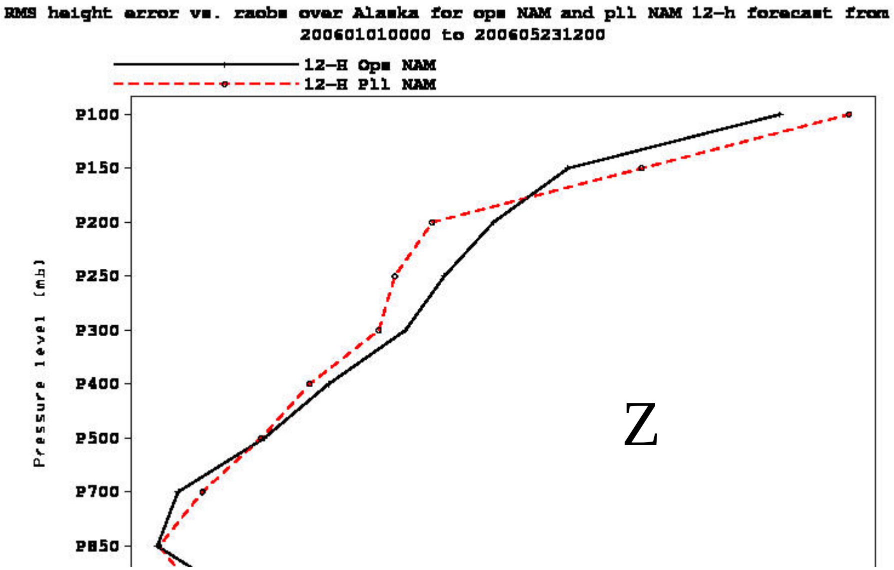


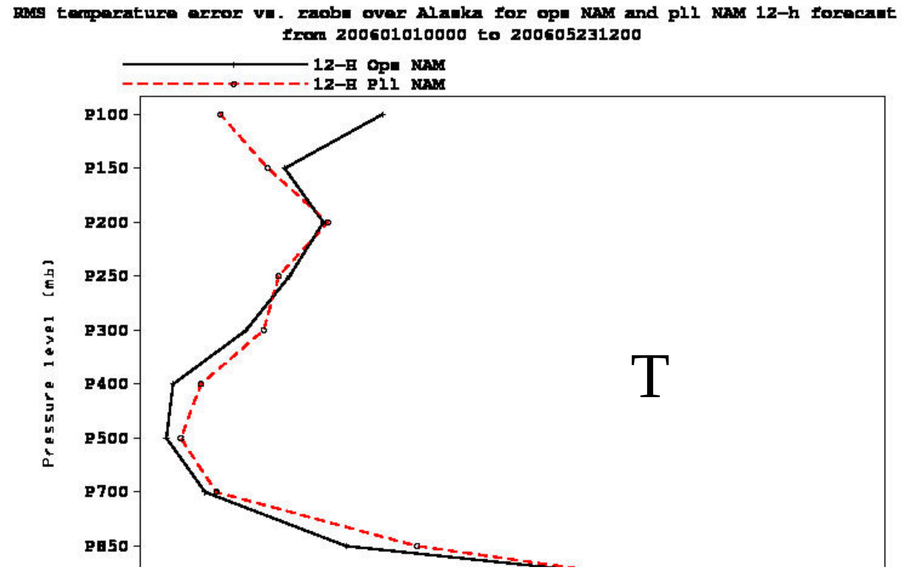


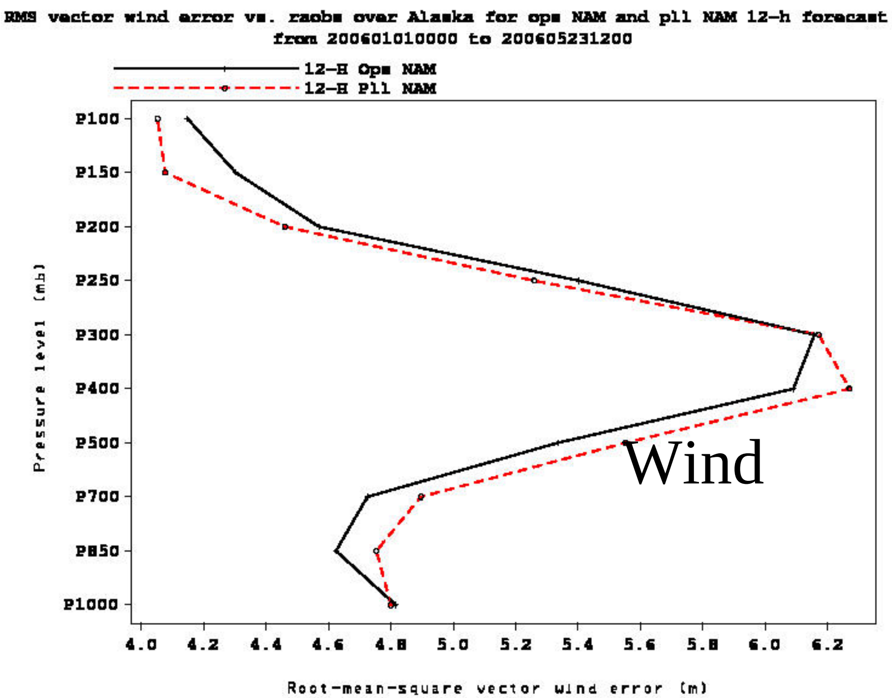


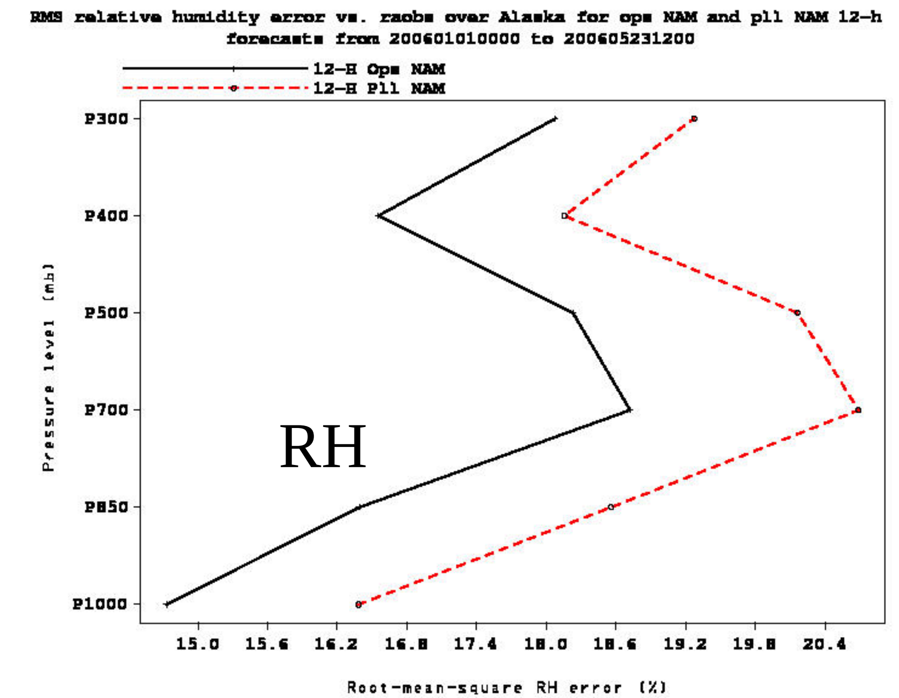


12 hr Alaska Statistics vs RAOBs

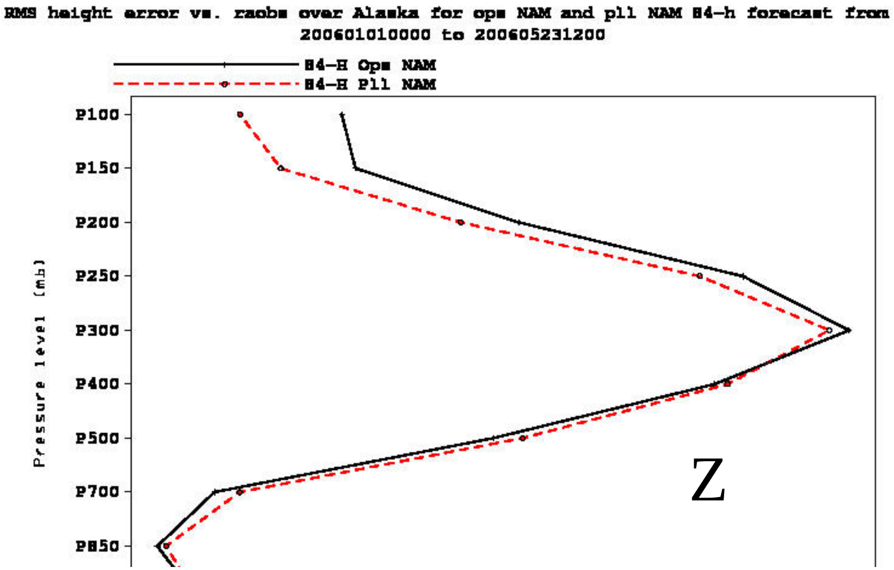


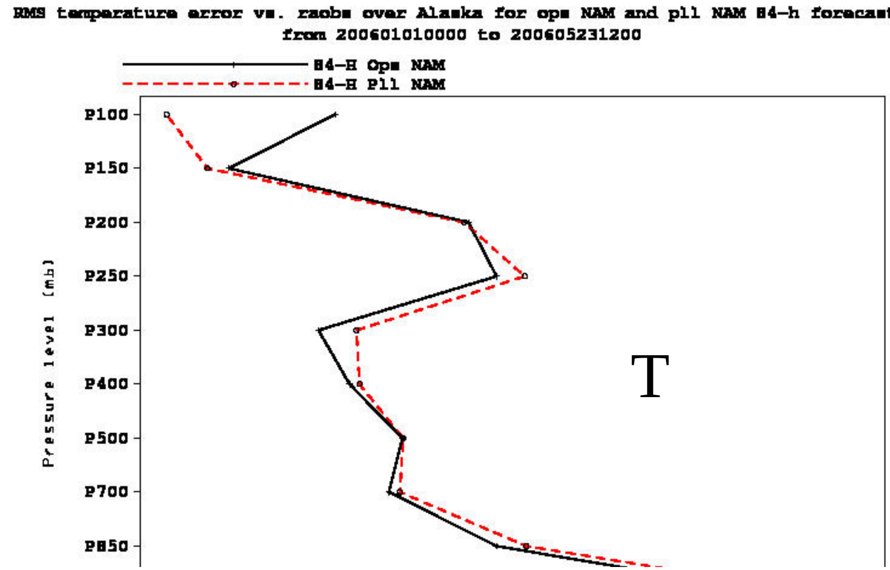


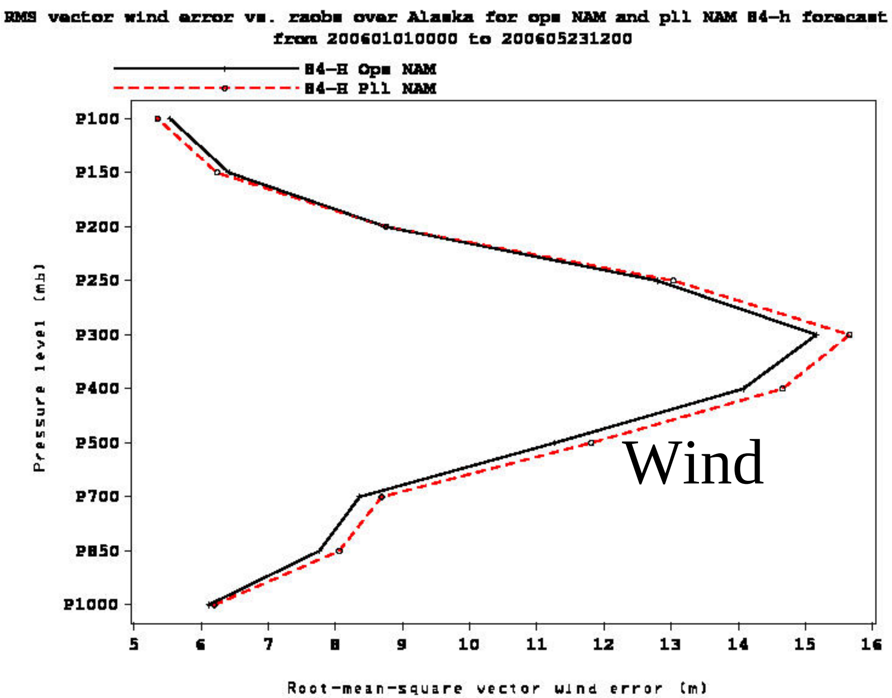


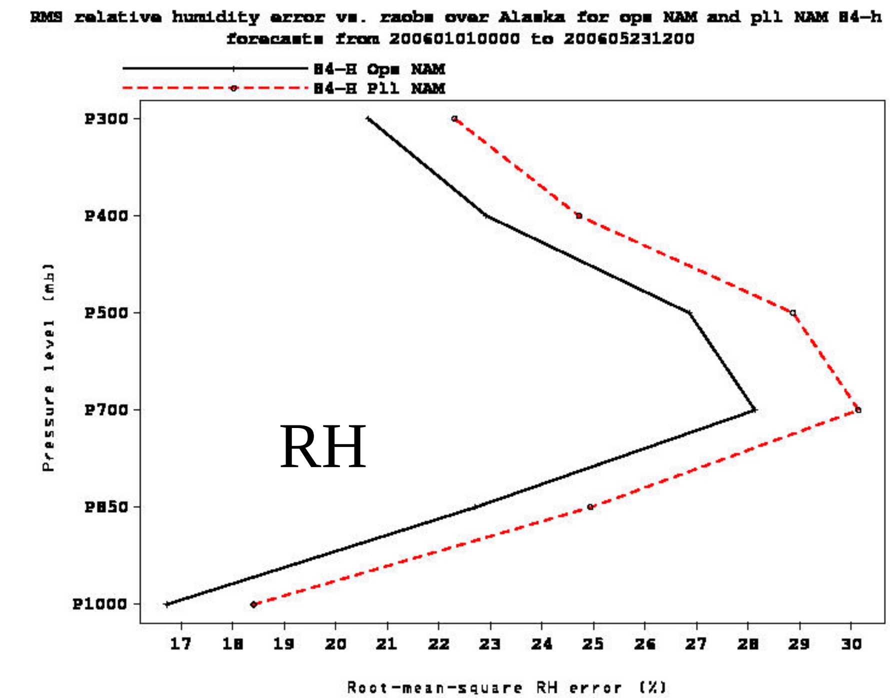


84 hr Alaska Statistics vs RAOBs



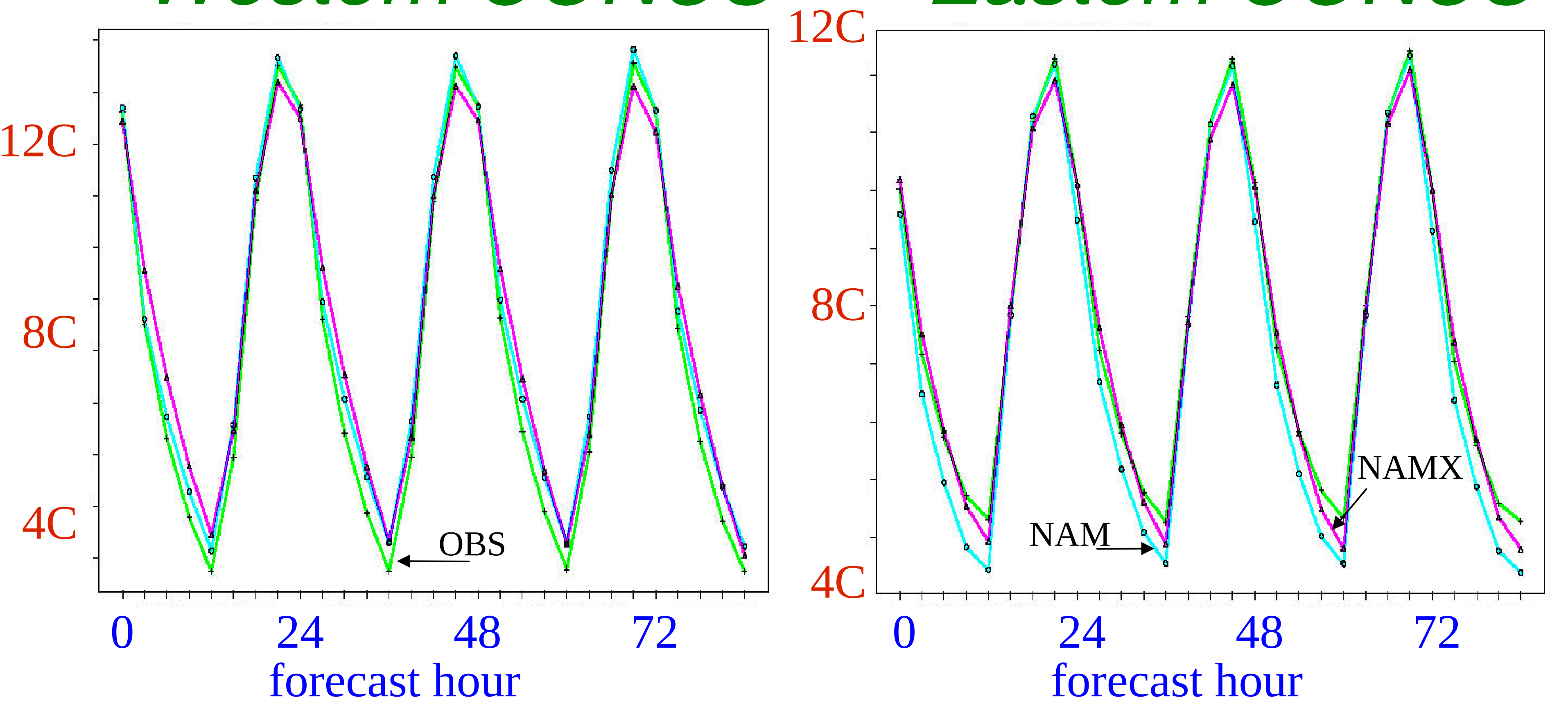






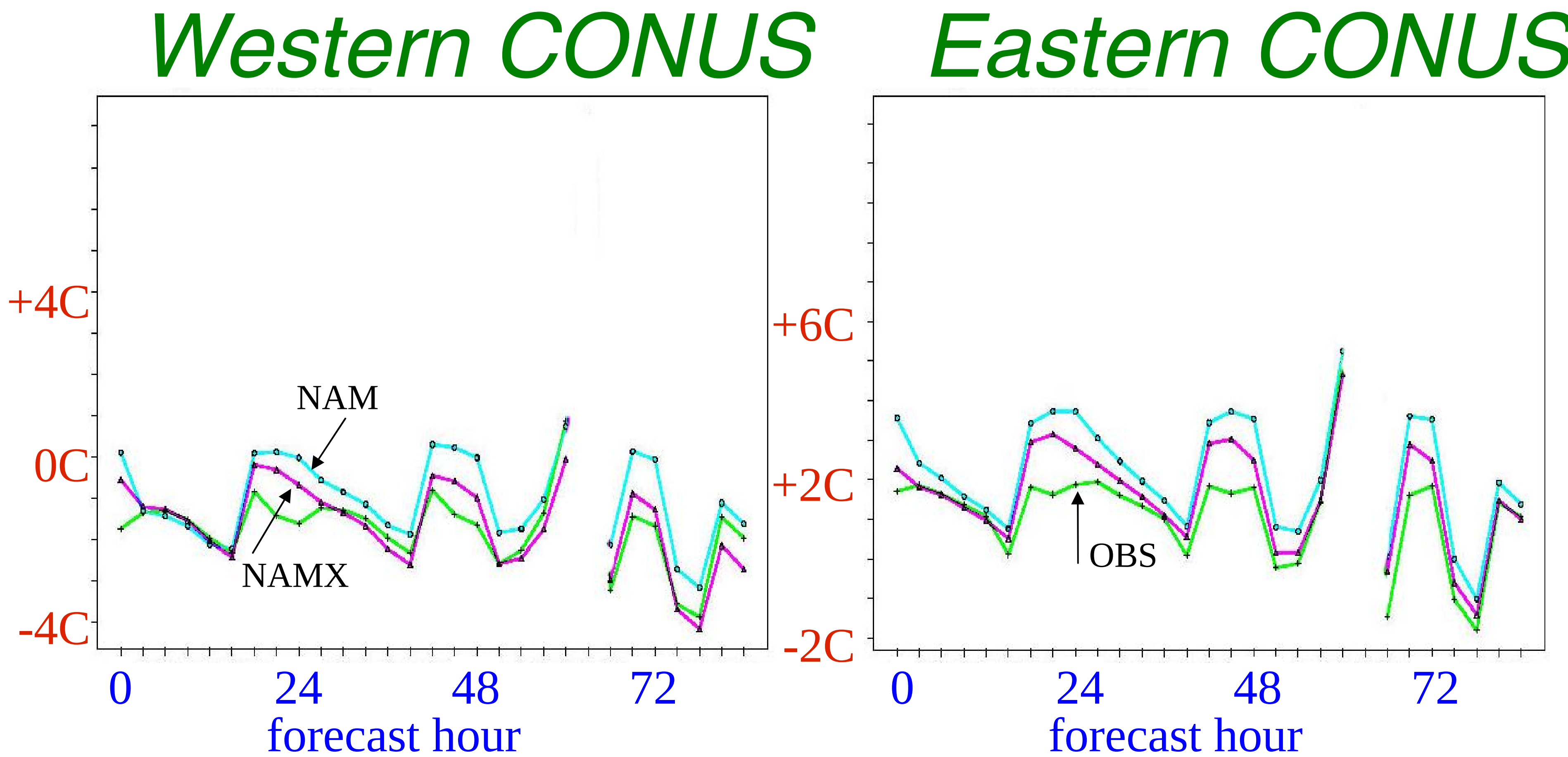
JAN-MAY 2006, 2-m Temperature

Western CONUS *Eastern CONUS*



- Comparable performance between NAMX and NAM
- Improved nighttime NAMX performance in the east

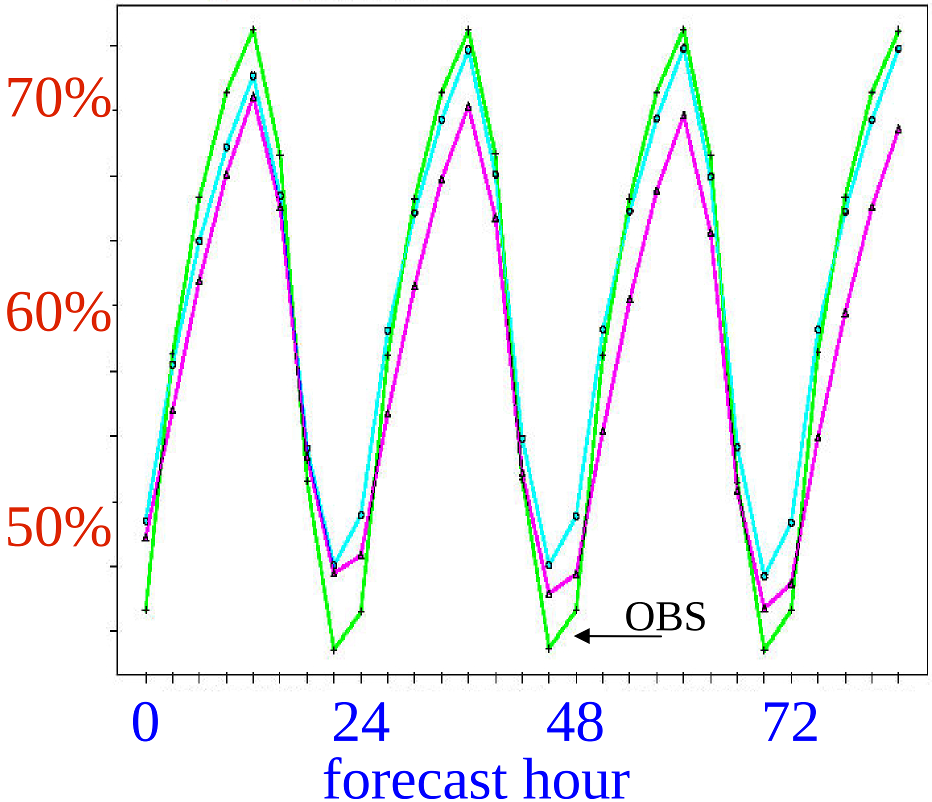
JAN-MAY 2006, 2-m Dew Point



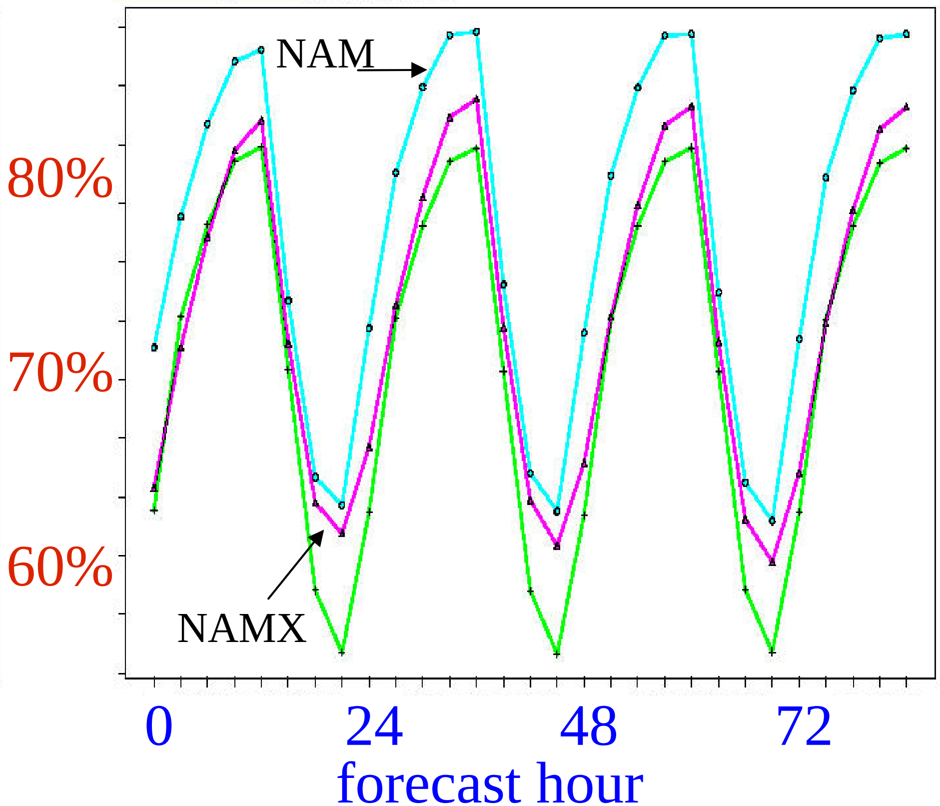
- Improved NAMX performance, esp. daytime
- Reduced moist bias in NAMX

JAN-MAY 2006, 2-m RH

Western CONUS



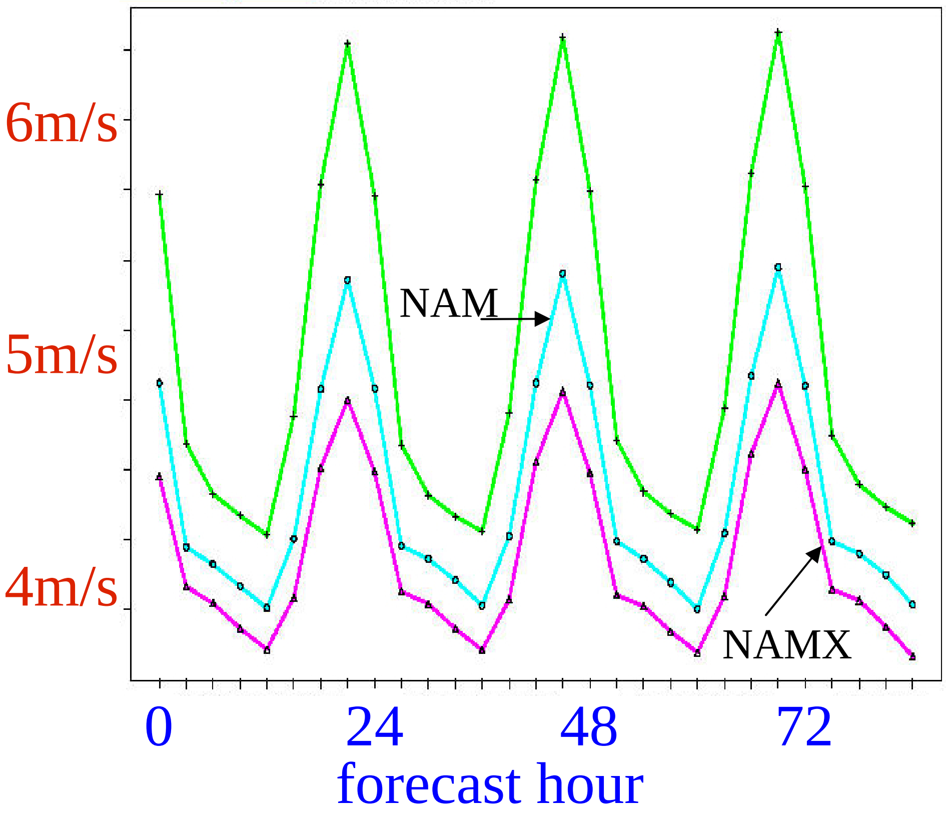
Eastern CONUS



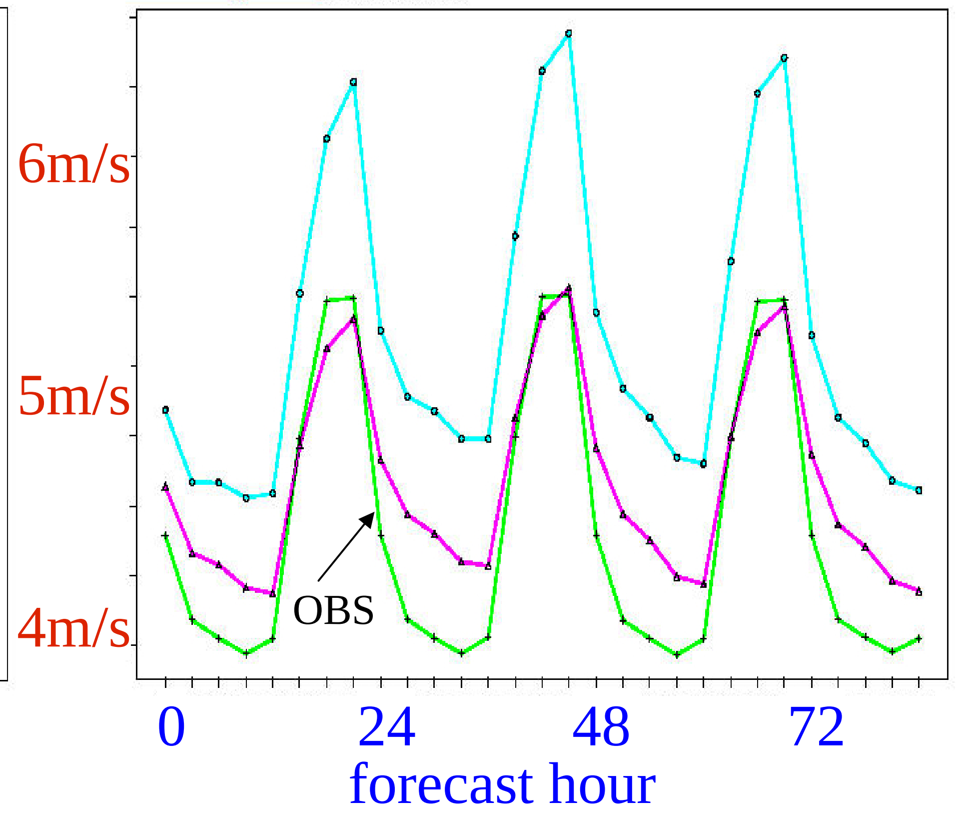
- NAMX: slightly less daytime moist bias
- Much less nighttime NAMX moist bias in east

JAN-MAY 2006, 10-m Wind Speec

Western CONUS



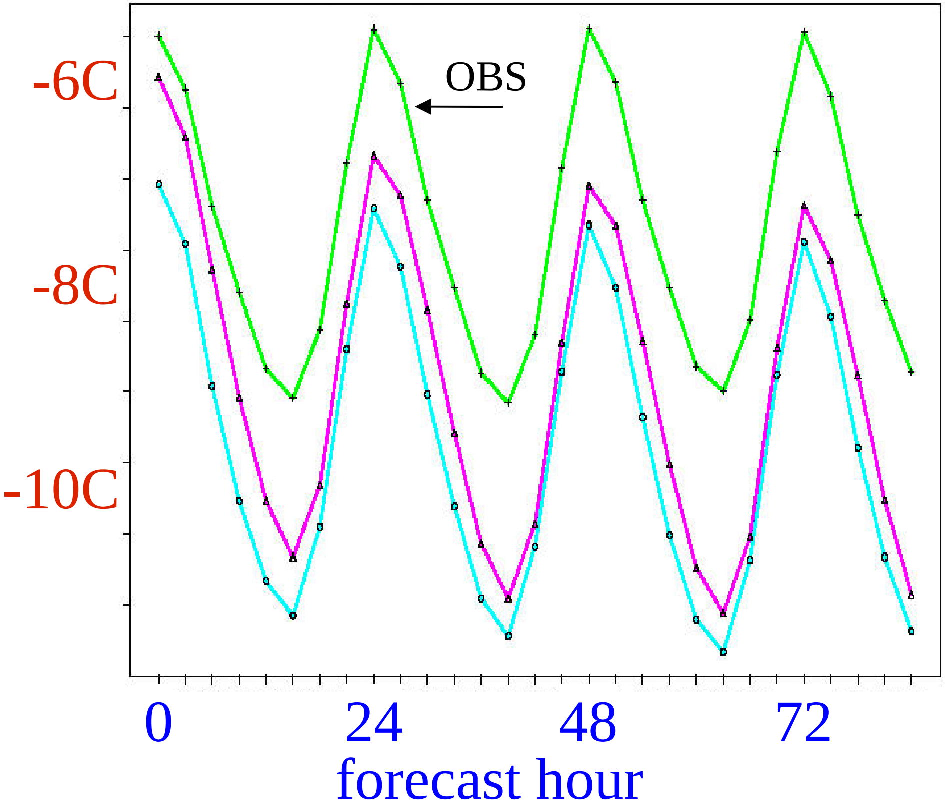
Eastern CONUS



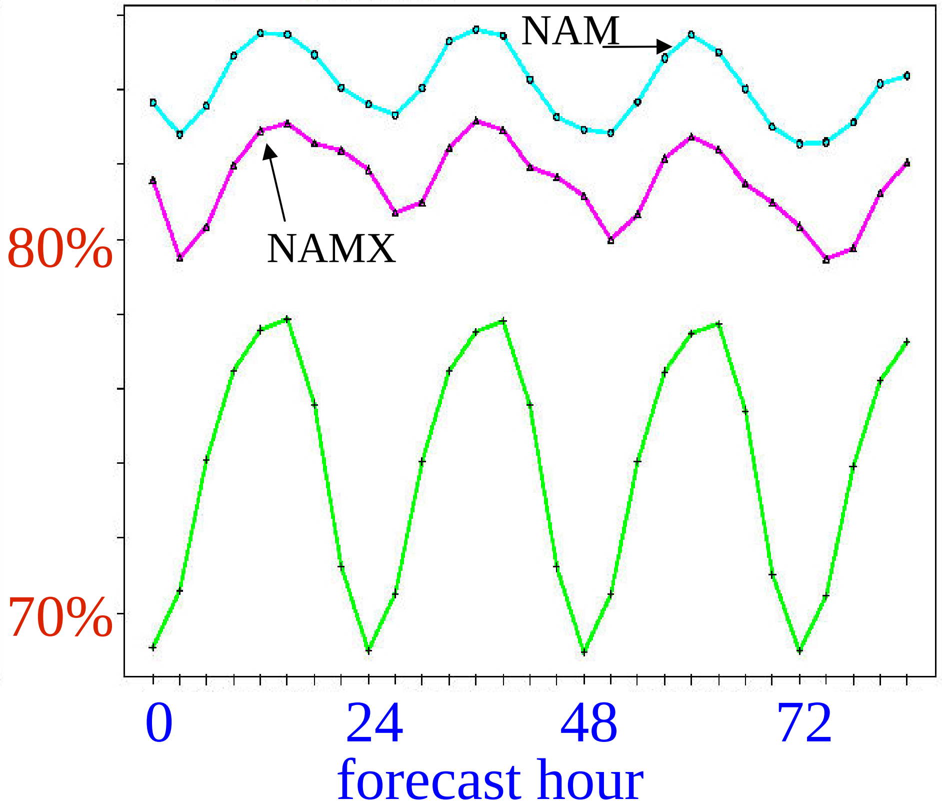
- NAMX: improvement in east with very low bias, esp. day
- Slightly more low bias compared with NAM in west

JAN-MAY 2006, ALASKA

2-m Temperature



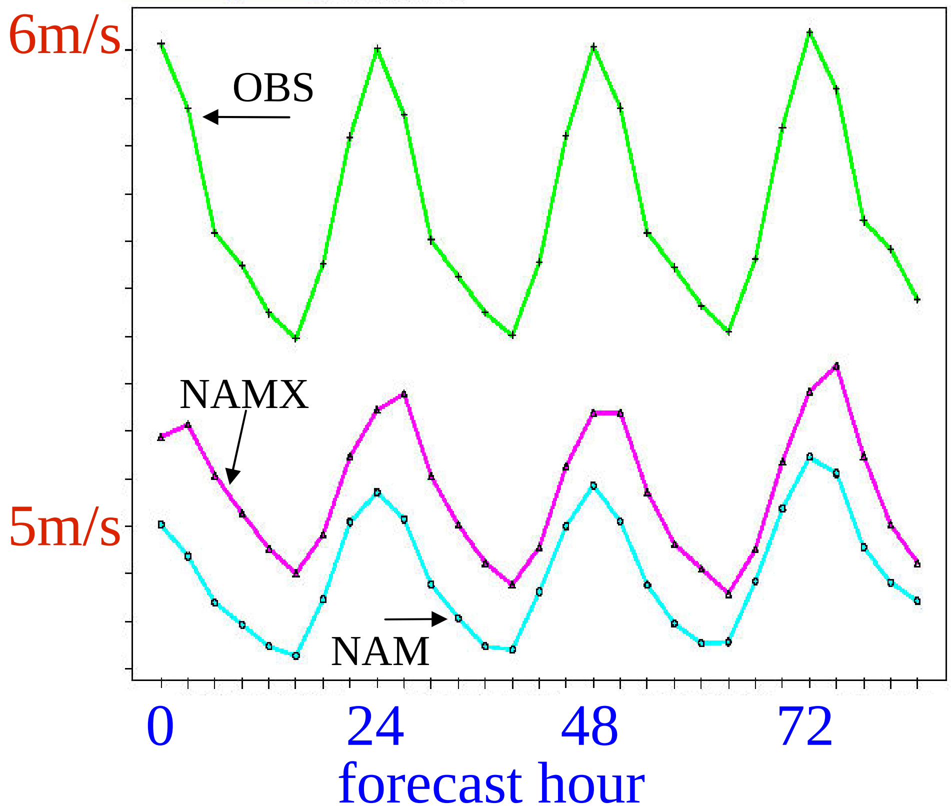
2-m RH



- NAMX: reduced cold, moist bias

JAN-MAY 2006, ALASKA

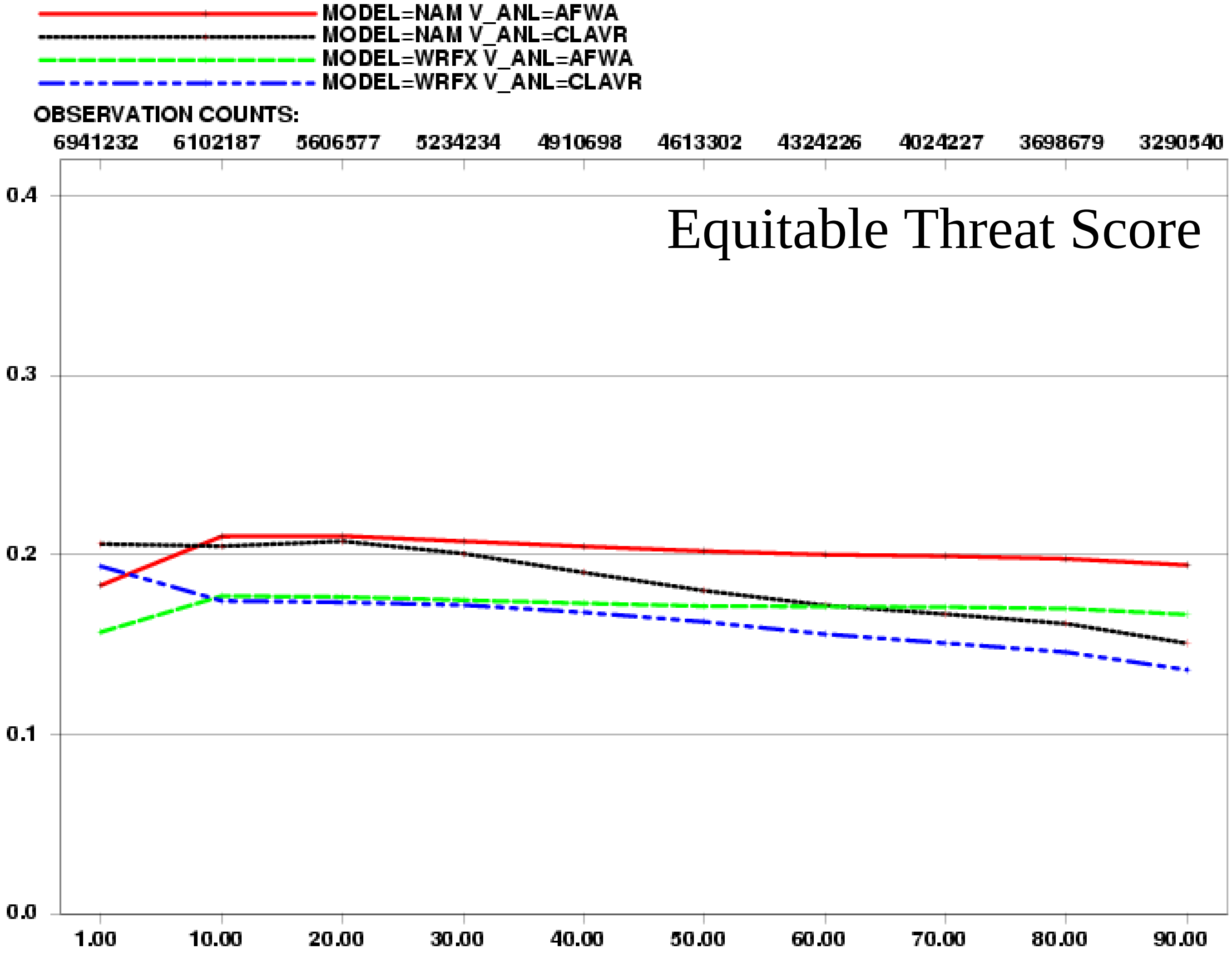
10-m Wind Speed



- NAMX: reduced low wind bias

Predicted Total Cloud Versus AFWA and CLAVR

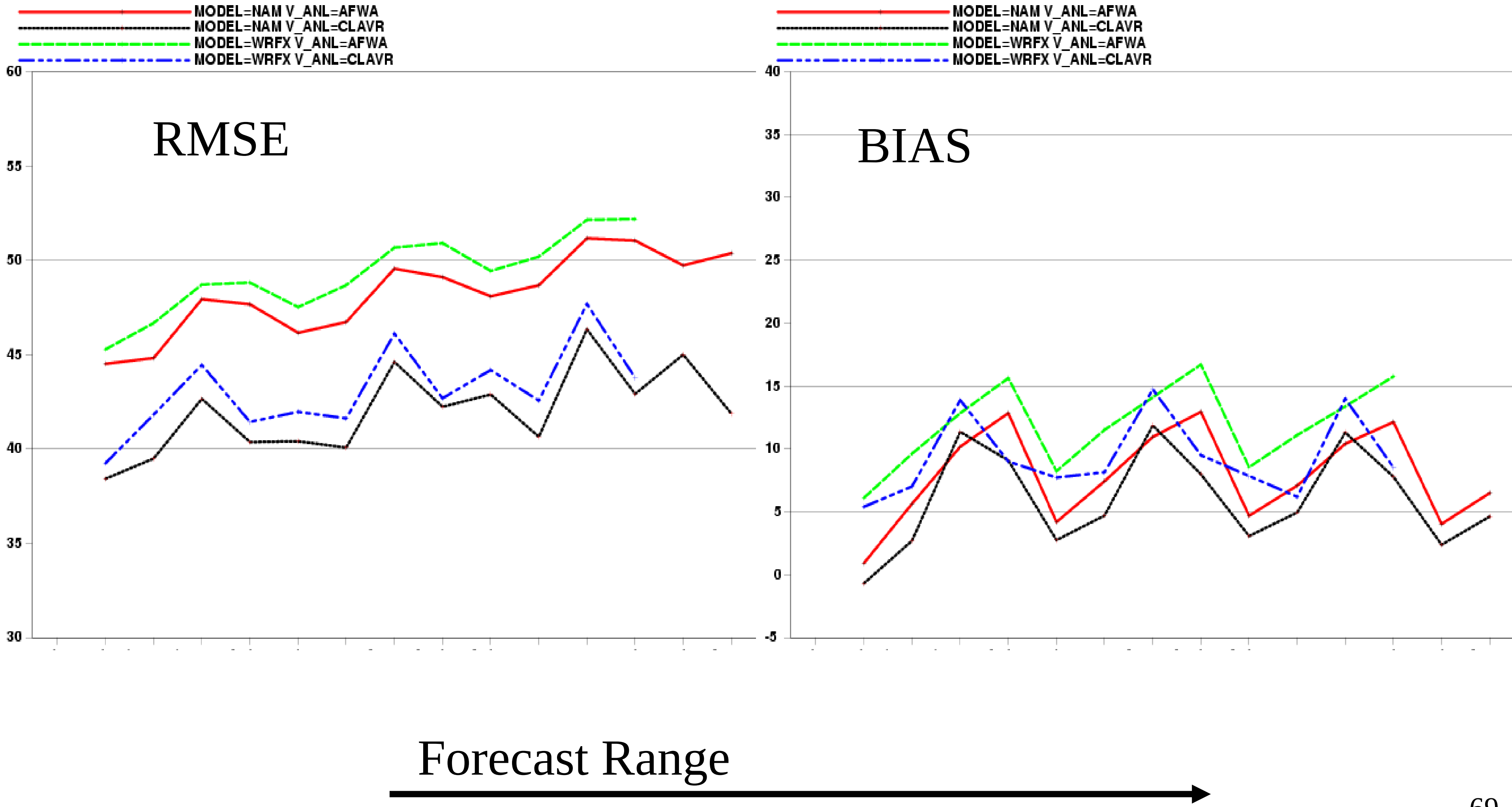
http://www.emc.ncep.noaa.gov/mmb/wd22jm/verif/cloud/



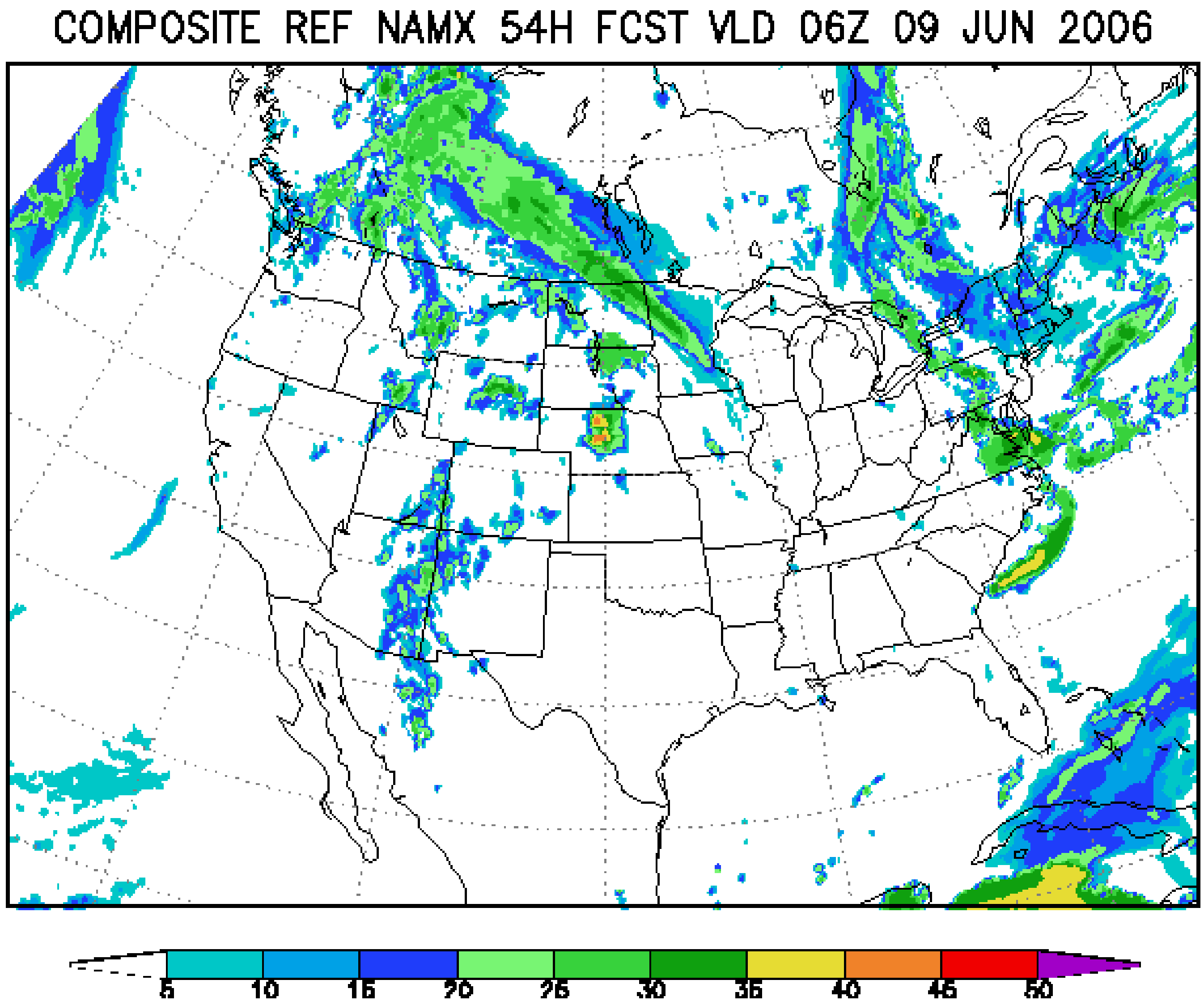
Cloud Amount Category

Predicted Total Cloud Versus AFWA and CLAVR

http://www.emc.ncep.noaa.gov/mmb/wd22jm/verif/cloud/



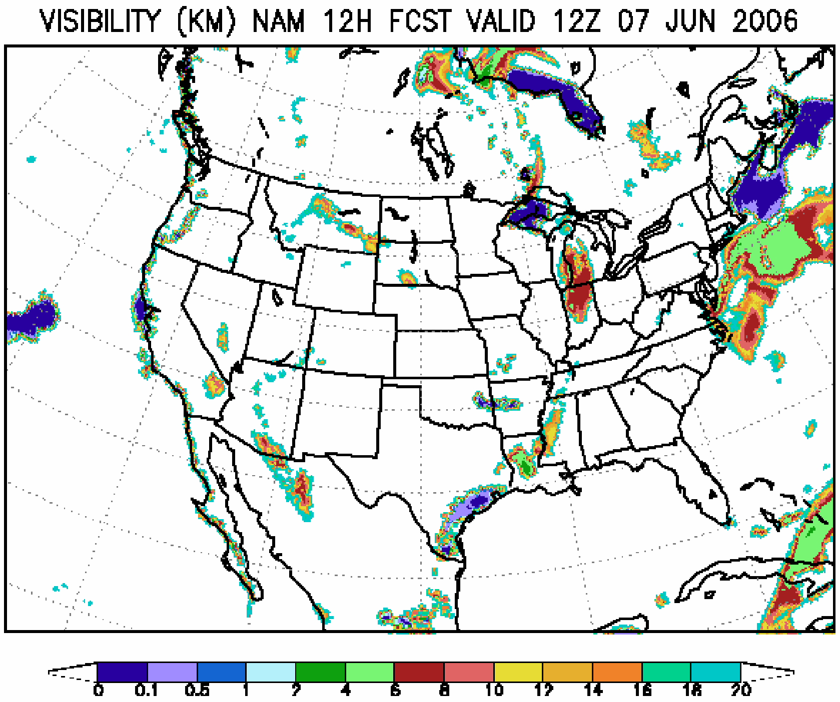
Simulated Reflectivity

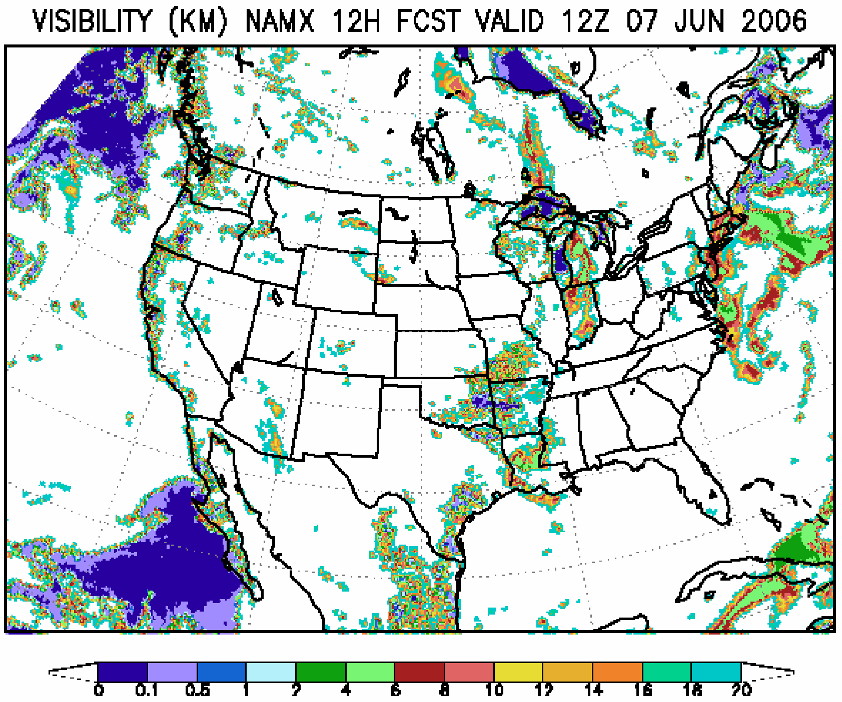


Improved Visibility

☐ Click to animate

f00 f03 f06 f09 f12 f15 f18 f21 f24 f27 f30 f33 f36 f39 f42 f45 f48 f51 f54 f57 f60 f63 f66 f69 f72 f75 f78 f81 f84

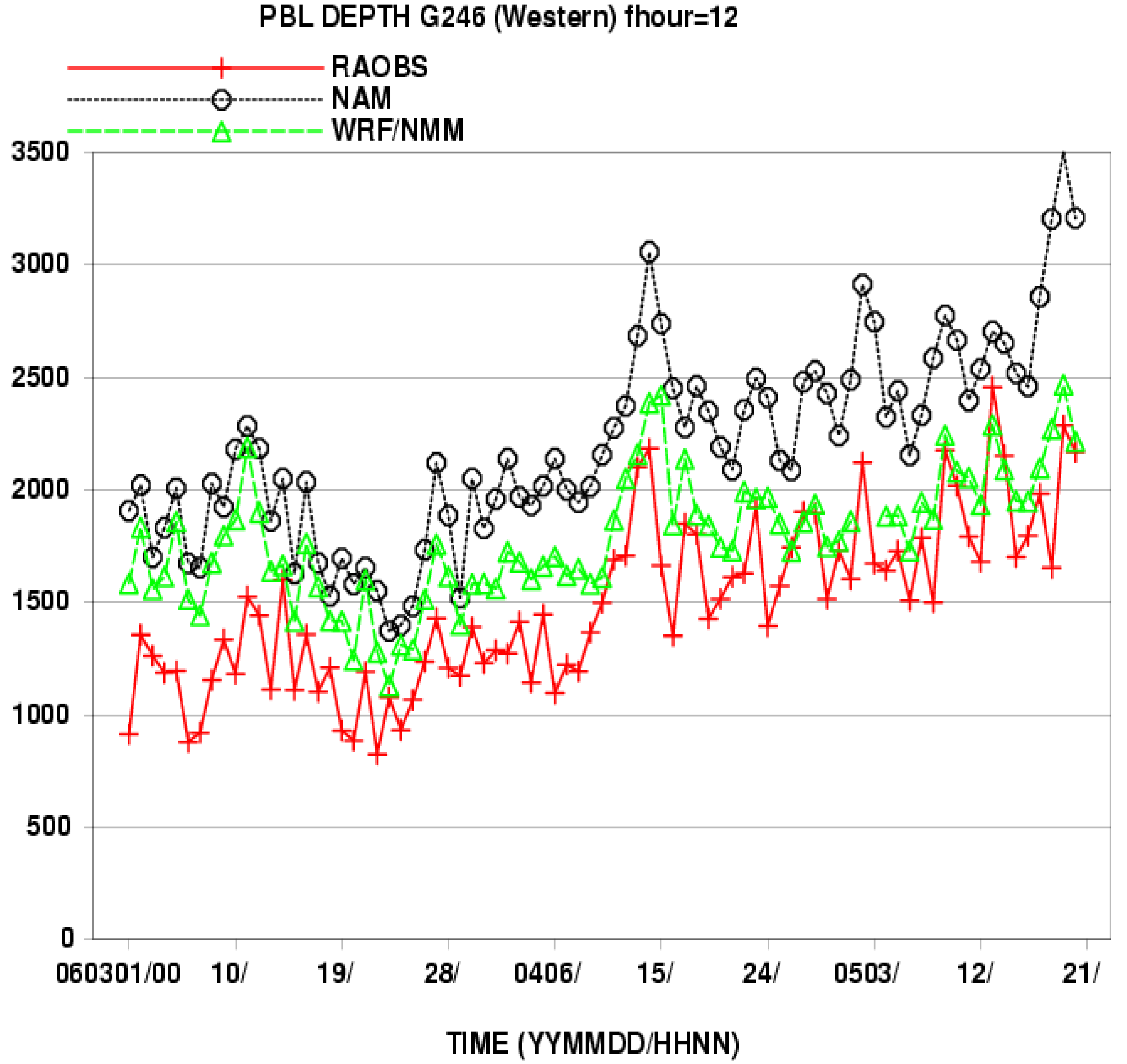




PBL Height vs Raob (diagnosed)

Results for western CONUS for the period Mar-Apr-May 2006

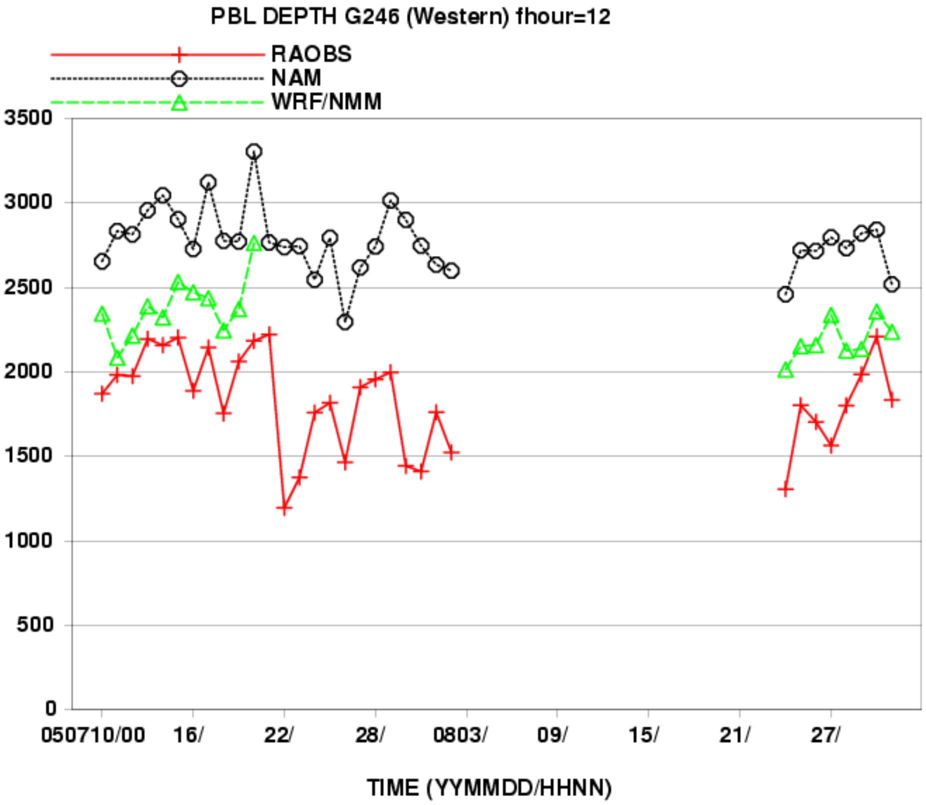
PBL collapsing in the east at this time



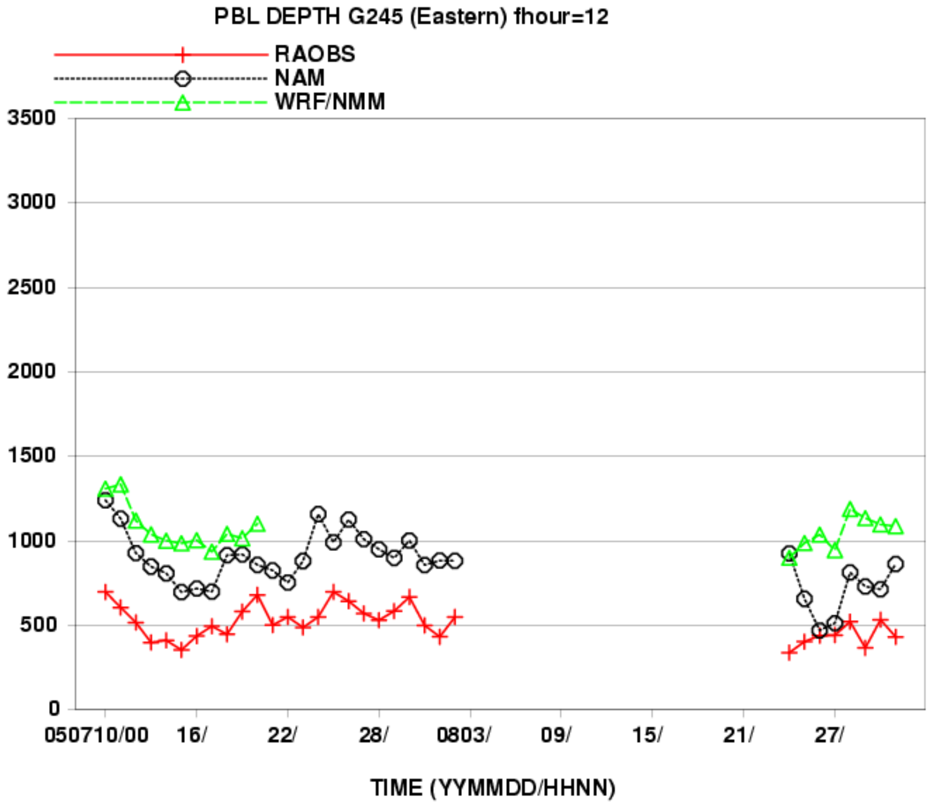
PBL Height vs Raob (diagnosed)

Results for the retrospective parallel period July-Aug 2005

West



East

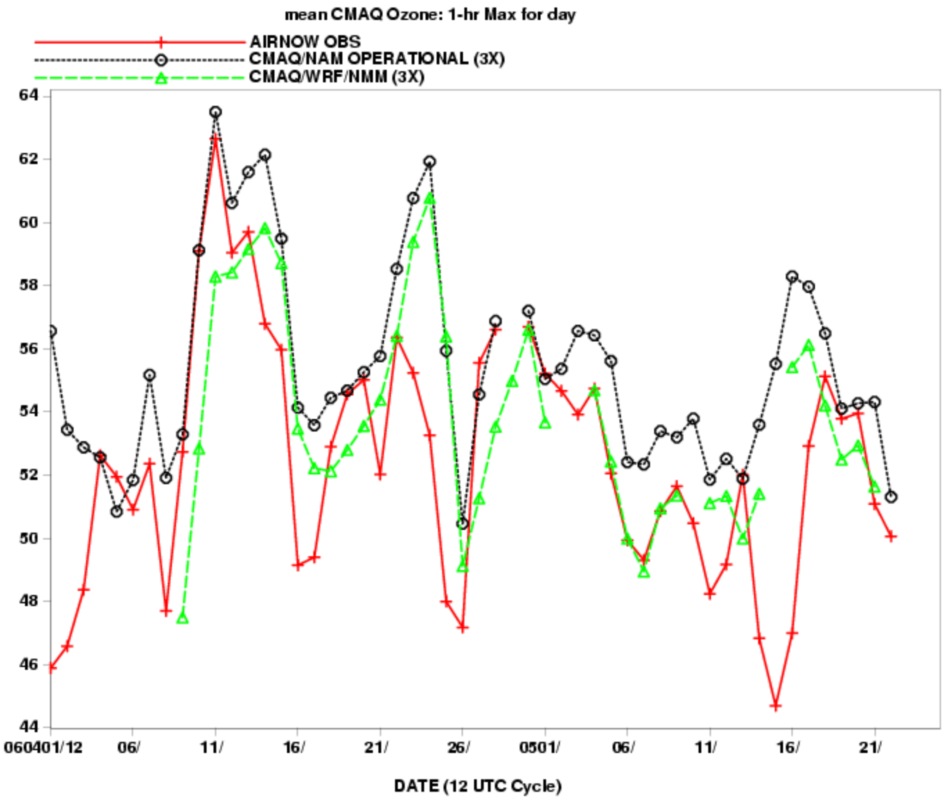


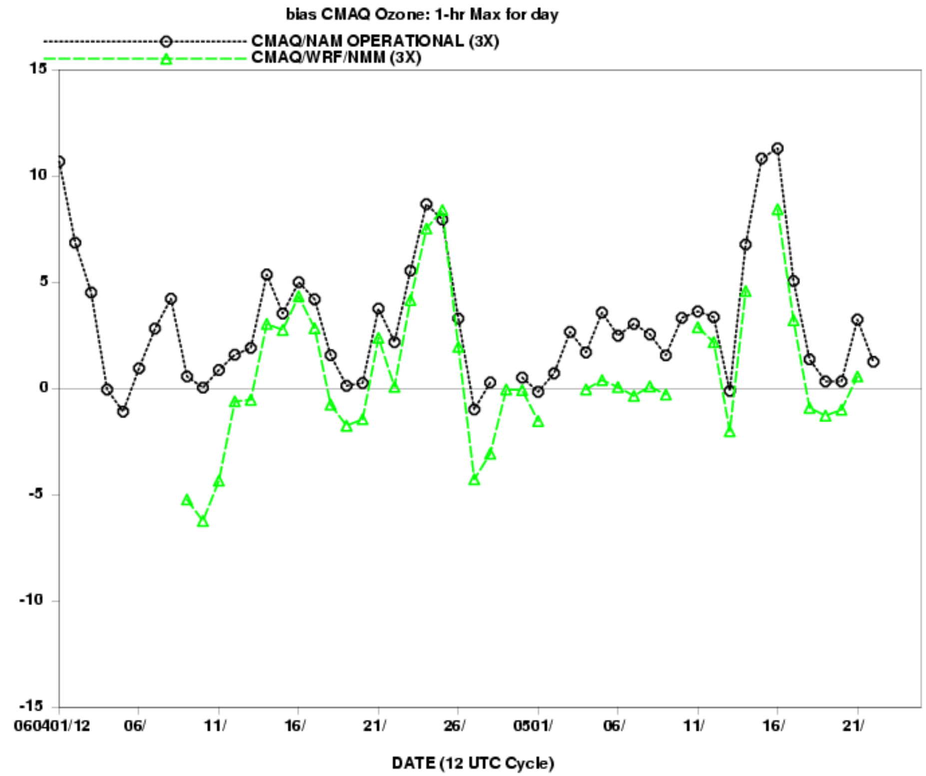
Surface ozone concentration (ppb)

1-Hr Daily Max

Mean

Bias





Apr-May 2006

Eastern US (3X)

Apr-May 2006

Webpage With All Evaluation Materials

http://www.emc.ncep.noaa.gov/WRFinNAM/

- Extensive training package developed by COMET’s Stephen Jascourt distributed by NCO to all evaluators on April 12, 2006 http://www.meted.ucar.edu/nwp/NAMWRF/splash.htm

NCEP Service Center Evaluations

SPC Steve Weiss and Jack Kain

- Clearly, the improved low level moisture in the NAM-WRF is high on the priority list for SPC, and this will be the driving factor for the SPC recommendation to implement.
- However, we have also seen a couple of days when a too shallow PBL advecting inland from the Gulf into TX resulted in surface moisture mixing out in the parallel (this did not occur in the operational NAM). The drier low level environment over land then spread northward across TX/OK in day 2/3 time frame resulting in limited instability and more sparse precipitation forecasts.
- Pre-convective sounding structure and PBL evolution are a thumbs sideways. Neither Eta nor NAM-WRF handle PBL evolution reliably; this is indeed a challenging forecast issue. Parallel soundings sometimes exhibit small-scale "noise" in temperature profiles immediately above the top of the PBL - this characteristic was not produced in operational version. I'll provide a couple of example figures next week.

NCEP Service Center Evaluations

SPC Steve Weiss and Jack Kain

- Precipitation during severe episodes is also a thumbs sideways. On some days the parallel was judged better, and other days the operational was judged better. Included in this are several outbreak days when the operational was considered better than the parallel. Not surprisingly, performance was generally best when forcing for large scale ascent was strongest, whereas precipitation timing/location/evolution guidance was typically less useful during weakly forced situations.
- A silver lining may be that reduced diffusion in the WRF can result in more detailed structure, especially at 12 km grid length, and indications of stronger precipitation core tracks (e.g., implied stronger persistent "cells") can be seen at times in the 3-hourly accumulated precipitation. This typically was not seen in the operational.
- There was a period of time during the end of April when there was larger than typical uncertainty in the large scale pattern evolution in the Day 2/Day 3 time period for several days (this showed up well in the SREF). In retrospect, the operational forecasts were better than the parallel. Further study might pin down the role played by the GSI vs the model.

NCEP Service Center Evaluations - SPC

- **Recommendation: Implement as proposed (cautious thumbs up)**
- **Low level moisture**
  - *Better in WRF (thumbs up)*
- **Pre-convective PBL sounding structure**
  - *WRF often different but not necessarily better (thumbs sideways)*
- **Precipitation**
  - *WRF often exhibits more detailed structures (thumbs up)*
  - *At times WRF evolution is difficult to understand (thumbs sideways)*
  - *For severe wx forecasting, WRF sometimes better; Eta sometimes better (cautious thumbs sideways)*
- **Synoptic patterns**
  - *Generally similar, although some evidence that WRF predicts deeper 500 mb troughs compared to Eta (thumbs sideways)*

NCEP Service Center Evaluations

AWC - Steve Silberberg

- Real-time AWC evaluation of NAM/NAM-Parallel
  - Wind & Turbulence diagnostics (Ellrod)
  - Water Vapor (RH, DP, Spec Hum)
  - Stability (LI, K, CAPE/CIN)
  - S-W Visibility
- 250 hPa STJ, vert wind shear, & Ellrod **stronger** in NMM → improved turbulence guidance
  - NMM STJ ~20 kt stronger at F06, F12, F18, F24
  - NMM Ellrod signature at model convection (vertical momentum transport)
- NMM RH equivalent to NAM-Eta
- NMM Stability equivalent to NAM-Eta
- S-W Visibility equivalent to NAM-Eta

NCEP Service Center Evaluations - AWC

- **Recommendation: Implement as proposed**

- AWC says Thank You
  - EMC for development
  - NCO for dataflow

NCEP Service Center Evaluations

HPC Pete Manousos

- **Retrospective Run Evaluation Comments:**
- **HPC evaluated a number of HPC specified warm season (July – Aug 2005) retrospective cases via a web page set up by EMC. HPC set out to evaluate warm season QPF and QPFs from tropical cyclones using these cases. Overall the non-tropical NAMP QPF did not outperform the NAM over the different regions of the CONUS that were evaluated (NW, NE, plains, SW, and SE). Nor did it perform any worse.**
- **Regarding QPF from tropical cyclones, overall the NAMP allows tropical cyclones to persist longer than the NAM, thus producing heavier QPFs. The NAMP signal for heavier rainfall was usually more correct. Additionally NAMP tended to better predict the location of the tropical cyclone related QPF maxima compared to the NAM. It should be noted the slower track of the NAMP was too slow compared to the observed track.**

NCEP Service Center Evaluations

HPC Pete Manousos

- **Real-Time Parallel Run Evaluation Comments:**
- **HPC evaluated NAMP from March 6 - May 19 2006 by our short term forecast and International Desks. Overall the MASS field forecasts by the NAMP represent an improvement over the NAM, and therefore non-convective QPF by the NAMP tends to edge out the NAM QPF.**
- **Serious issues remain with the NAMP QPF. Both our QPF desks and International Desks have noted that the NAMP does not offer any advantage over the NAM for convection (not surprising since both utilize the same parameterization scheme). A significant QPF performance issue was the unfavorable bias of emphasizing significant QPF (>.50”/12hr) too far north of where convection verifies. This is especially noted along the path of surface cyclones – both the NAMP and NAM tend to under predict the convection along the boundaries south of surface cyclones - thereby fostering an over prediction of much moisture flux north to the low level convergent region represented by the surface cyclone. At times the over prediction of convection in the low results in an over prediction of surface low deepening – which then results in a negative (performance relative) feedback process.**

NCEP Service Center Evaluations

HPC Pete Manousos

- **Real-Time Parallel Run Evaluation Comments continued:**
- **We also noticed the NAMP often holds up the frontal precip (i.e., over prediction of precipitation behind the dryline and at times cold fronts). One forecaster did note the low level moisture seemed to be forecast better by the NAMp than the NAM yet at the same time the overall convective forecasts by the NAMP seemed to offer less run to run continuity than the operational NAM.**
- ***Given the consensus of overall subjective improvements of mass field forecasts by the NAMP over the NAM, the slightly worse performance of convective QPF, an on par or slightly improved performance in cool season QPF, and an improvement for QPF associated with tropical cyclones, ultimately our recommendation is to IMPLEMENT AS PROPOSED. One of the major reasons for the recommendation is the improvement in the forecast of mass fields. If it were not for this improvement, HPC would not recommend implementation because of the noted issues with QPF.***

NCEP Service Center Evaluations - HPC

- **Recommendation: Implement as proposed**

- **NOTE: We wish to thank EMC and NCO for making this output available to HPC – particularly for allocating a sufficient evaluation "window" (2 months) to discern performance. Additionally, we wish to thank EMC's Matt Pyle for his efforts in setting up the retrospective web page used by HPC QPF forecasters during the evaluation. Finally, we wish to thank NCO's Brent Gordon and EMC's Eric Rogers and Brad Ferrier for facilitating the "satellite look alike" tests (inclusion of TOA OLR in the NAMP output).**

NCEP Service Center Evaluations - OPC

Recommendation: Implement as proposed

- **OPC’s Pacific (60-250 nm) & Atlantic (25-250 nm) forecasters reviewed WRF performance daily:**
  - **Many noted ocean cyclones (location and intensity) initialized better than NAM-Eta (GFS too sometimes)**
  - **Several noted NAM-WRF analyses comparable to ECMWF**
  - **NAM-WRF predicts deeper ocean cyclones than NAM-Eta (too weak) and sometimes even deeper than the GFS**
  - **Off both coasts, NAM-WRF 10m winds were stronger than NAM-Eta and, at times, GFS; several forecasters noted that the NAM-WRF 10m winds were an improvement over the GFS and NAM-eta over the colder (more stable PBL) waters.**

NWS Regional Evaluations –Alaska

Carven Scott and James Nelson Anchorage WFO

Recommendation: Implement as proposed

"AFC gives the NAM-WRF an unqualified thumbs-up over the NAM-Eta."

Experience somewhat limited due to AWIPS-build issues stopping ingest for several weeks, however, the following observations were noted:

- **Like OPC, NAM-WRF initialization better than NAM-Eta for ocean cyclones … at least equal to the GFS for western Pacific and Bering systems, and superior in the East Pacific/Gulf of Alaska.**
- **Lows appear to be systematically deeper (better) than the NAM-Eta**
- **Definitely handles lee-side lows in the northern Gulf of Alaska far superior to either the NAM-Eta or the GFS… significant because lee side low/trough dictates depth & location of marine layer and stratus with maritime safety implications for recreational and small commercial fishermen in the north Gulf.**
- **Handles better the easterly waves that ride up coast into south central Alaska which impact likelihood, onset and intensity of convection in south central Alaska.**
- **Handles better the embedded minor lows and frontal systems rotating around the major cut-off lows in the north Pacific**
- **Precip spin-up and QPF seem consistently superior with NAM-WRF**
- **Triple-point low development appears superior to GFS and NAM-Eta.**

NWS Regional Evaluations

Central: Tom Hultquist

Recommendation: Implement as proposed

- **Subjective review done by a number of offices within the region. Relatively few comments were received, but**
  - **All feedback was positive and supportive of implementation.**
  - **General comments indicated that forecasters felt the guidance was an improvement over the current operational NAM**

NWS Regional Evaluations

Eastern: Jeff Waldstreicher

Recommendation: Implement as proposed

"Overall, the NAM-WRF has been equal to or a little superior to the NAM-Eta."

Some specific items noted by Eastern Region forecasters:

- **NAM-WRF 2m dew points are better than the NAM-Eta. This is a known significant problem for the Eta. The evaluation period was not long enough to declare this a "problem solved," but the WRF Tds were notably improved**
- **The NAM-WRF appeared to have better initial conditions and short term forecasts (6-12 hour projections) than the Eta-NAM. There were a number of instances noted of poor F6 and even F12 Eta forecasts of QPF and 700 mb omega when the WRF (and often the GFS as well) were superior.**
- **WFO CLE noted several cases during April & May where frontal positions in the NAM-WRF were superior to the NAM-Eta**
- **The NAM-WRF depiction of precipitation structures was more realistic than the NAM-Eta**

NWS Regional Evaluations

Eastern: Jeff Waldstreicher

- **The NAM-WRF did have some notable less-than-optimal forecasts during the evaluation period, but fewer than the NAM-Eta, and no more than one would reasonably expect from a state of the art mesoscale model. For example, the 12Z 4/20 NAM-WRF run did a very poor job in the F60-F84 time frame for a 4-8" rainfall event in the NY Metro area. The NAM-Eta and GFS were better, but not much. However, this same NAM-WRF run was notably superior to the other models regarding the timing, location and intensity of severe convection that moved through the Carolinas in the F36-F60 time frame.**

NWS Regional Evaluations

Southern: Bernard Meisner

Recommendation: Implement as proposed

"**We have not received any comments from our WFOs which would impact the planned June 13th implementation.**"

- **The opportunity to view the output was offered to all our field office, but we have no easy way to determine exactly which ones regularly viewed the output. We do know there were some, and I monitored the output on our AWIPS.**
- **We also appreciate the effort you and your staff invested in ensuring the field offices would have the opportunity to view the output on their AWIPS.**

NWS Regional Evaluations Western: Andy Edman

Recommendation: Implement as proposed

"… based on feedback from Oxnard, Reno, Salt Lake and the WRH evaluation offices, WR concurs with the decision to implement the NAM-WRF."

- **Excellent training/lessons learned material was produced by Randy Graham of Salt Lake City, UT office.**
- **Similarly from Dave Danielson of the Oxnard, CA office.**

Air-Quality Program Evaluation: Paula Davidson

Recommendation: Implement as proposed

Comments re impacts on operational predictions of ground-level ozone:

I. Summarizing our team discussion of May 2, concerning WRF and Eta-driven CMAQ predictions, that focused on April 24-28. The comparisons are for operational AQ forecast domain (Eastern US, or the so-called “3X”).

- For 3X predictions, WRF-CMAQ 1-hr avg daily max values for ozone are slightly lower than Eta-CMAQ by about 2 ppb.

- Diurnal cycling is reduced with WRF: for 8hr avgs, about 13ppb difference max-min for WRF; compared to Eta: 18ppb; and obs: 23 ppb. This also seen in nighttime minima more overpredicted with WRF than with Eta. - Patchiness (sharper lower gradients) may be greater with WRF-based predictions

- Jeff McQueen reported earlier that WRF uses smaller latent heat flux over land-- in better agreement with msmt. Pius noted that latent heat flux values in WRF may be too large over ocean. The group raised questions over how that may be related to generally lower values of predicted surface ozone.

- Marina Tsidulko reviewed her analysis of PBL heights: generally deeper for WRF in the Eastern US, but shallower in the western US. If no other changes were at work, this would be expected to cause somewhat lower ground-level ozone in the East and higher values in the west.

Air-Quality Program Evaluation

Comments continued:

II. We are continuing to monitor the differences, and the systematics described above appear to be continuing. An additional issue that may cause difficulties later in the summer, when recirculation of elevated ozone from the coastal areas to the Atlantic and then back, is more common

- Differences in ozone predicted over ocean:

Although comparisons with WRF- and Eta- driven CMAQ results from April 6? onwards have not shown dramatic systematic differences, for the forecast period valid Apr 29- May3, it appears WRF-based predictions show larger surface ozone over Atlantic than do Eta-based. Coastal ozone monitors did not show high ozone. All should continue to watch this as a potential issue-- various WRF configuration changes may have masked any systematic difference earlier in April. Concern if un-verified high ozone over Atlantic is associated with latent heat flux? LBC/PBL height?

- We are seeing impacts of higher model deposition velocities (in CMAQ) on predicted ozone—related at least in part to adjustments in WRF of LAI heat flux. We expect to investigate these impacts further; some additional available measurements may point to refinements.

Feedback on NAM (Eta) to NAM (WRF-NMM)

Earl S. Barker AFWA/XPFT

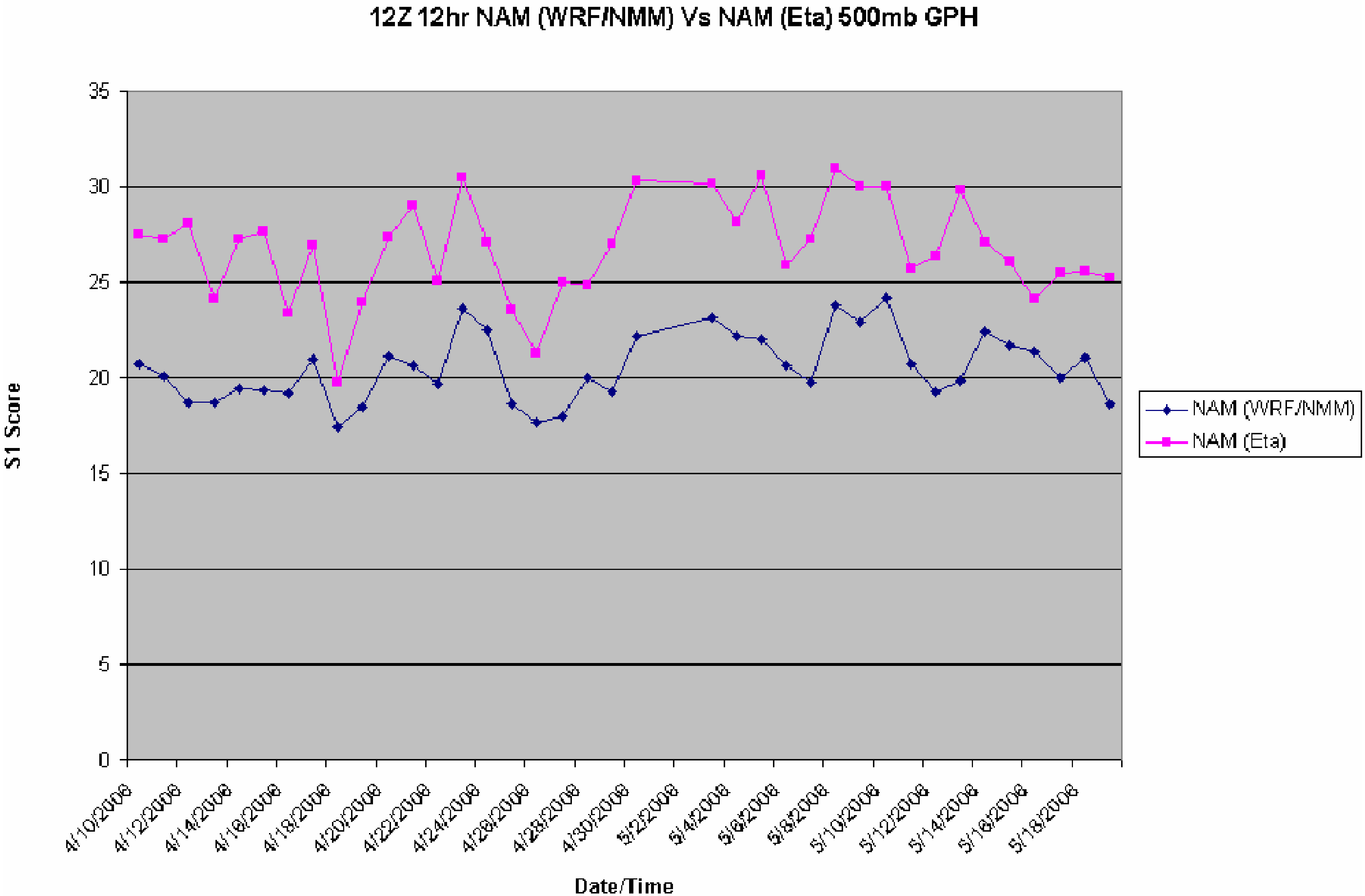
On 15 June 2006, Earl S. Barker AFWA/XPFT wrote:
Geoff,

[AFWA's] OPSII is looking forward to the upcoming switch from NAM (Eta) to NAM (WRF-NMM). Thanks for making the parallel runs of NAM (WRF-NMM) available beforehand so that our forecasters could get an idea of what types of bias, etc to expect. I noticed that you had a PDF file (I think dated June 7th) on the feedback from the NWS and private industry. I thought I would forward some graphs showing the S1 Skill Score for the 500 mb GPH for a period from 10 April to 19 May 2006 (your team most likely created lots of statistcal comparisons). Other than a few poor forecasts around the 23rd of April, NAM (WRF-NMM) did a better job than NAM (Eta), at least for this one statistical method for 500 mb GPH.

Thanks and good job!

Earl Barker

AFWA (via Barker) S1-Score Plot



Private Sector #1 Evaluation

Recommendation: none stated directly

"Geoff – A quick note thanking you and your group at NCEP for work on replacement of the existing ETA/NAM gridsets with WRF output .. Joe has pretty much completed the side-side comparison with our … end-end automated forecast systems running from the existing baseline and the test set of grids and everything looks good. This backwards compatibility I'm sure is difficult to get exactly right from the IT perspective, thus it is greatly appreciated that you accomplished this on time. It has saved us a lot of retrofitting work. Again, thanks.. We understand potential issues with new ETA MOS and will keep a sharp eye out for this."

Private Sector #2 Evaluation

Recommendation: none stated directly

- The NAM-WRF seems to be doing much better now that we are in the more convective season. The NAM-WRF is picking out more smaller scale type features and shows the convective nature of showers and thunderstorms in the warm season even better than the ETA. I still think the NAM-WRF will have problems with larger scale type development and the evolution of warm air advection situations that are on a larger scale. So, it looks as if we will have to compare and not average the NAM-WRF and GFS.

I think the weaknesses of the NAM-WRF will be made up by the GFS. Where the GFS has trouble handling smaller scale development we can rely more heavily on the NAM-WRF. Comparing the WRF to the ETA I believe during the warm season the NAM-WRF will be just as good and in many cases better. As we head into the colder season I think the WRF will either do just as good as the ETA or perhaps not quite so good. We did not have a good chance to see how the NAM-WRF handles good synoptic scale storm systems during the cold season like coastal development.

Private Sector #2 Evaluation

What little we did see was not impressive and in most cases we had to rely more heavily on the GFS. I will be very interested in seeing how the NAM-WRF does with smaller scale snow and ice situations. Based on what little we saw of the NAM-WRF during large synoptic scale storm systems I believe the model will have trouble with coastal development and perhaps handling of cut off lows. But it probably won't be too far off from what we have seen in the ETA version of the NAM.

Finally, the last submitted comment from forecasters about the NAM-WRF was focused on short range convection forecasts. This is a comment about the convection over PA Tuesday night:

Although the 18z nam-wrf suggested tstms would develop over us or very nearby before the 6z time step, the 00z run missed the whole thing. Considering areas just east of us seemed to get more than 3 inches of rain, that's unacceptable.

NCEP Service Center Subjective Evaluations

NCEP Center	Recommendation
AWC	
SPC	
HPC	
OPC	

Non-NCEP Subjective Evaluations

NWS Region	Recommendation
Alaska	
Central	
Eastern	
Southern	
Western	
Air Quality Program	

Performance Summary

- Upper-Air guidance overall comparable
  - Better than Eta at short range 12-36 hr
  - Tails off by 84 hours
- More realistic mesoscale structure than Eta
- Most surface variables and visibility improved with smaller biases than Eta
- More realistic oceanic and tropical cyclones

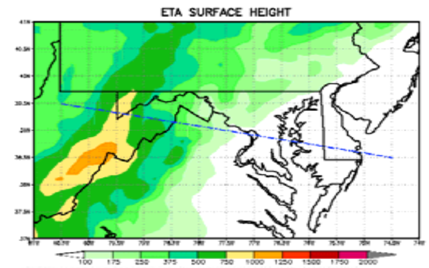
Remaining Issues

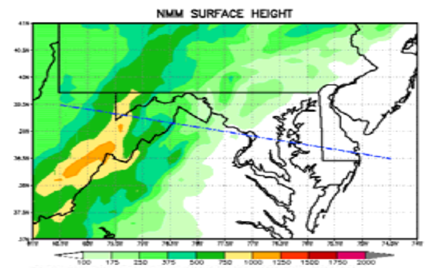
- Dry Drift with forecast range
- Over-deepening troughs (see Jascourt)
- Over active with tropical storms
- Unrealistically Shallow (ankle-deep) boundary layers
- Very short-range Precip Spin-Down (convective)
- Turn overland surface temperatures back on
- Need for extra levels in solving the radiative transfer equations (for radiance assimilation)
- Extract more information from Level II radial winds

BACKUP SLIDES

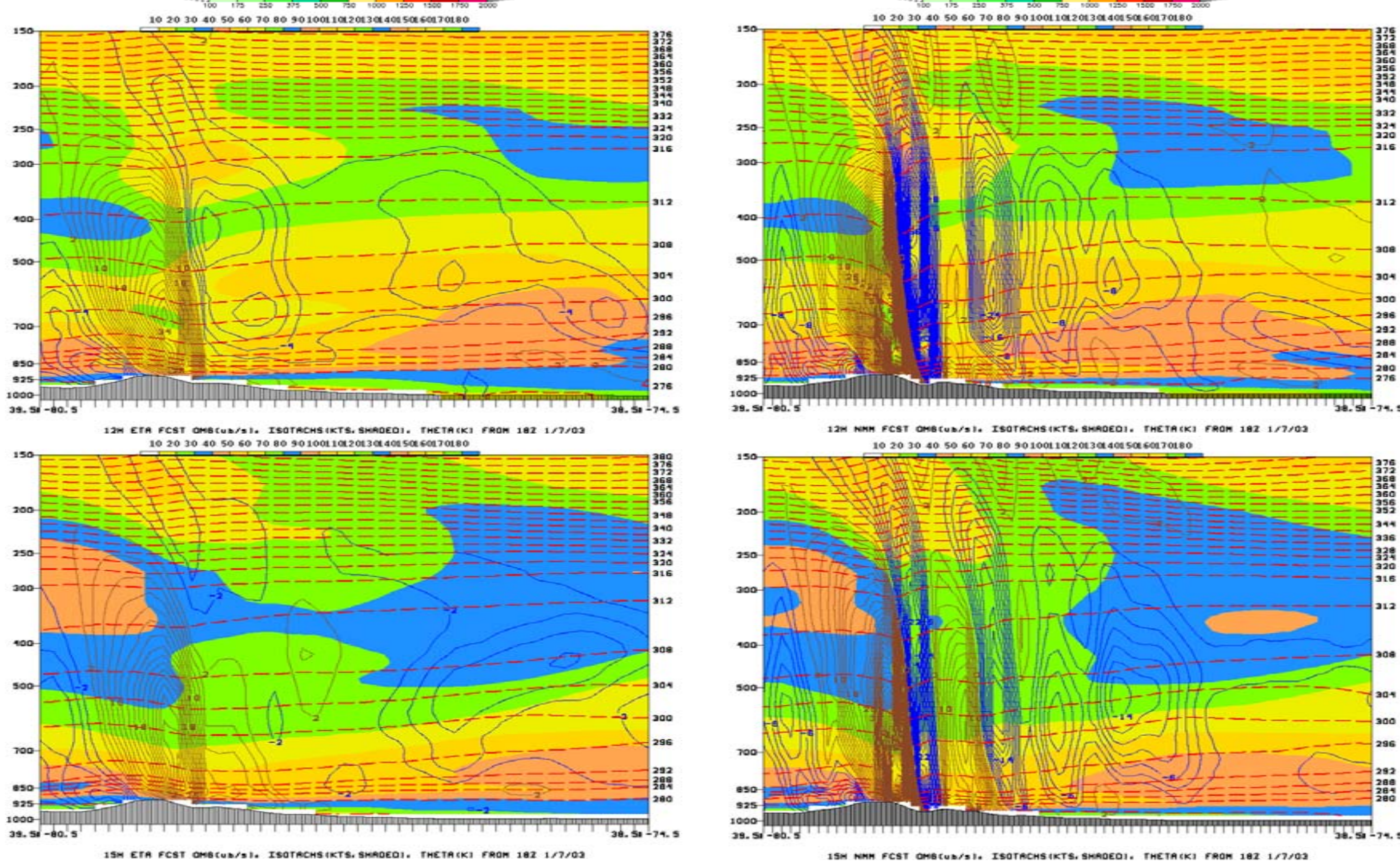
NMM Has Stronger Vertical Circulations Than Eta

Eta

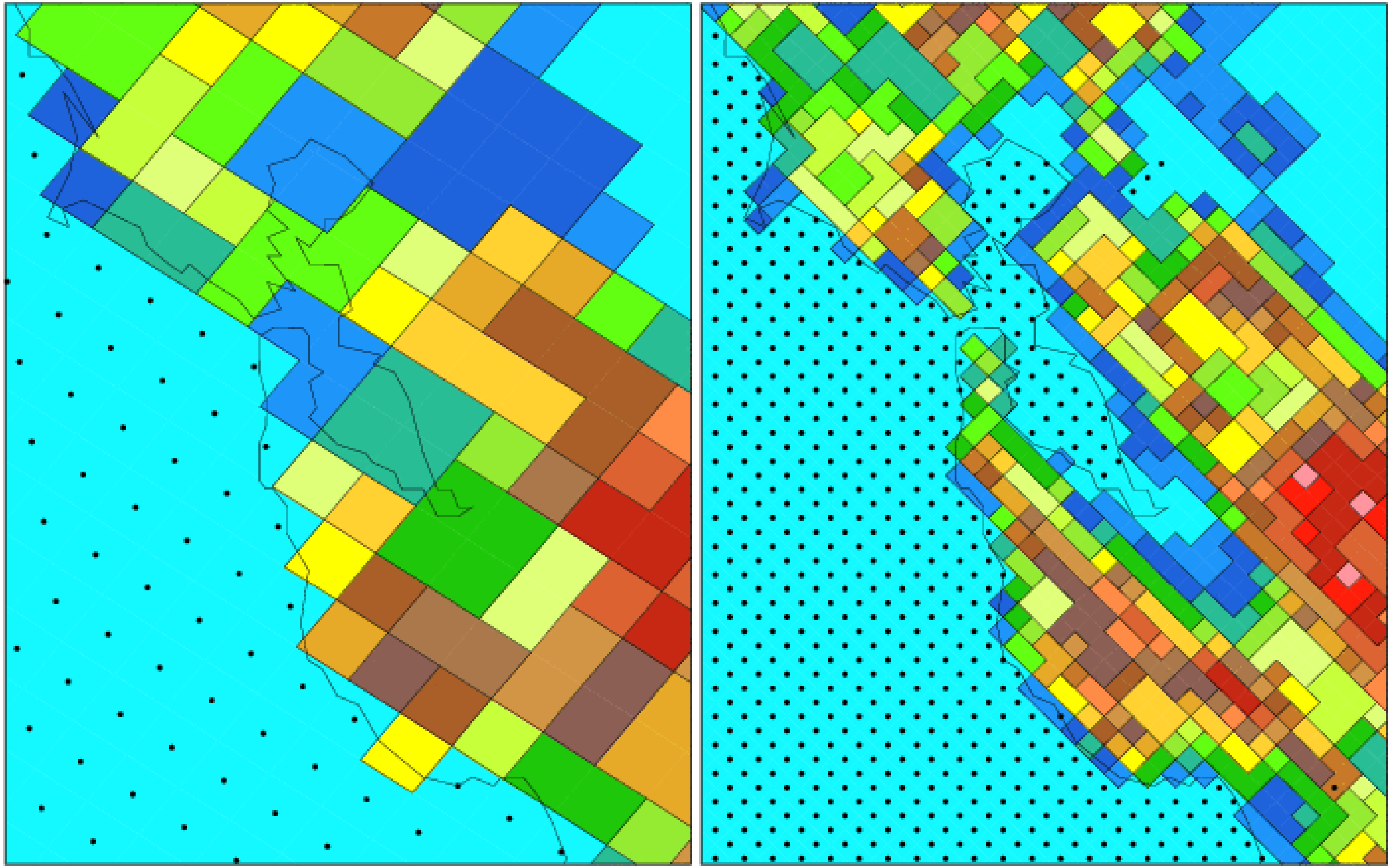




NMM

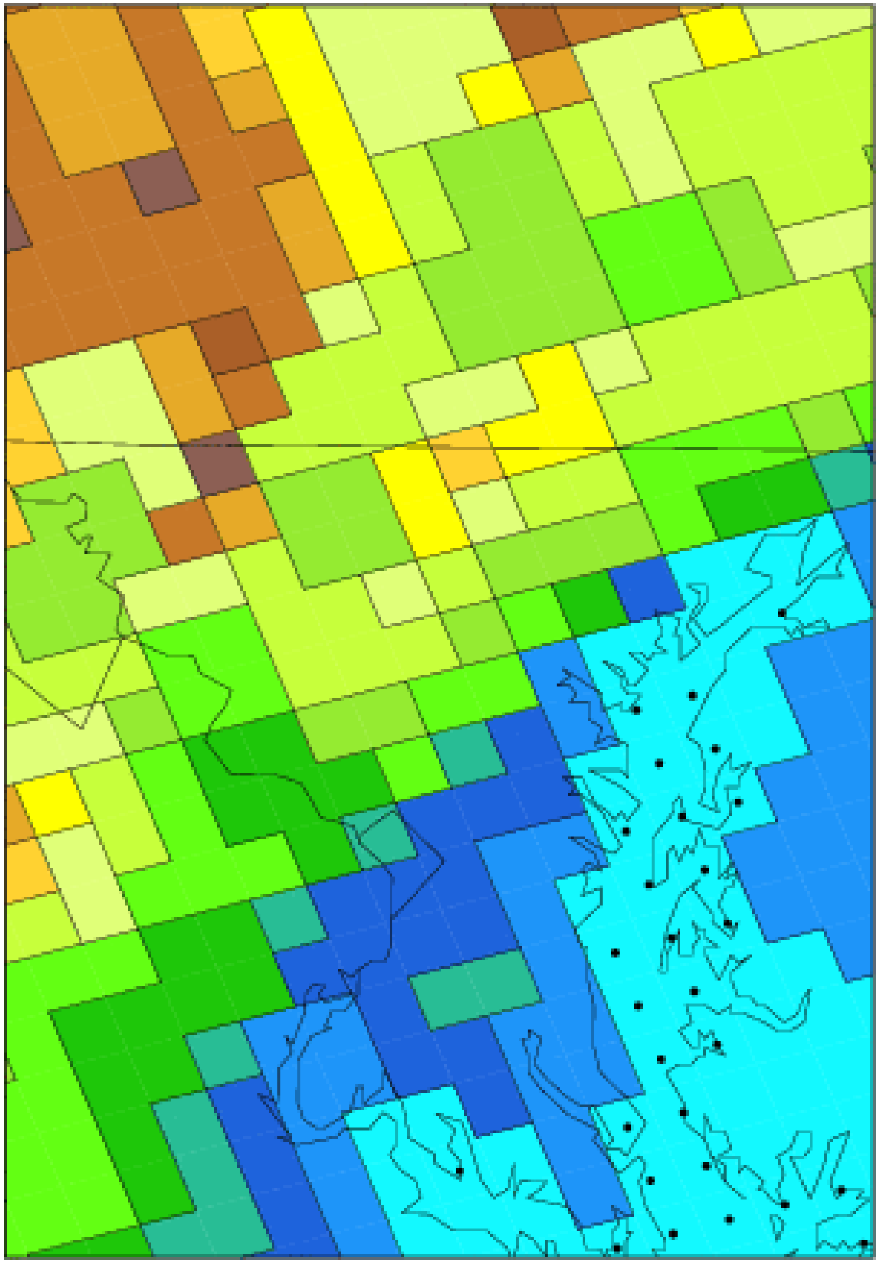


12 km Terrain 4 km Terrain

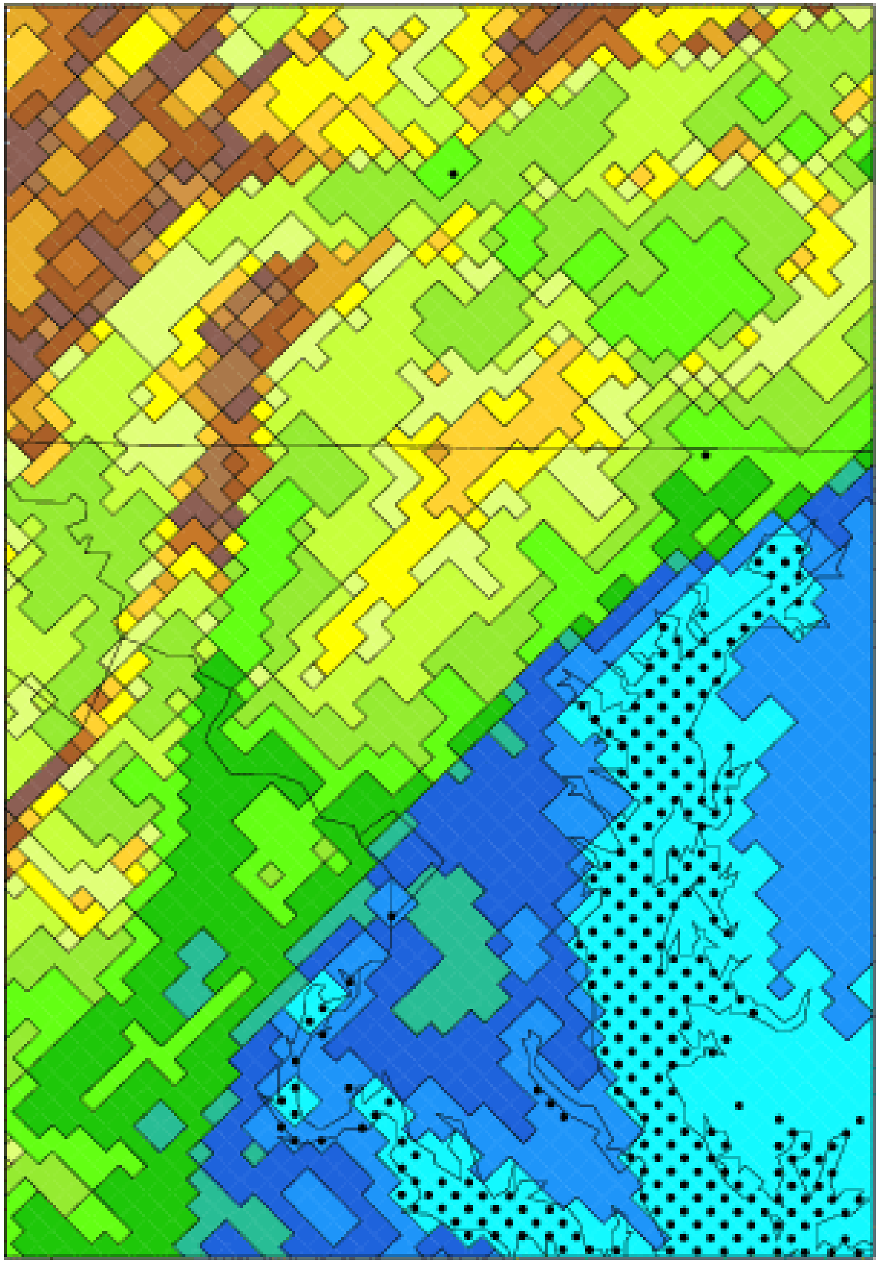


Dots represent water points Domain is San Francisco Bay

12 km Terrain

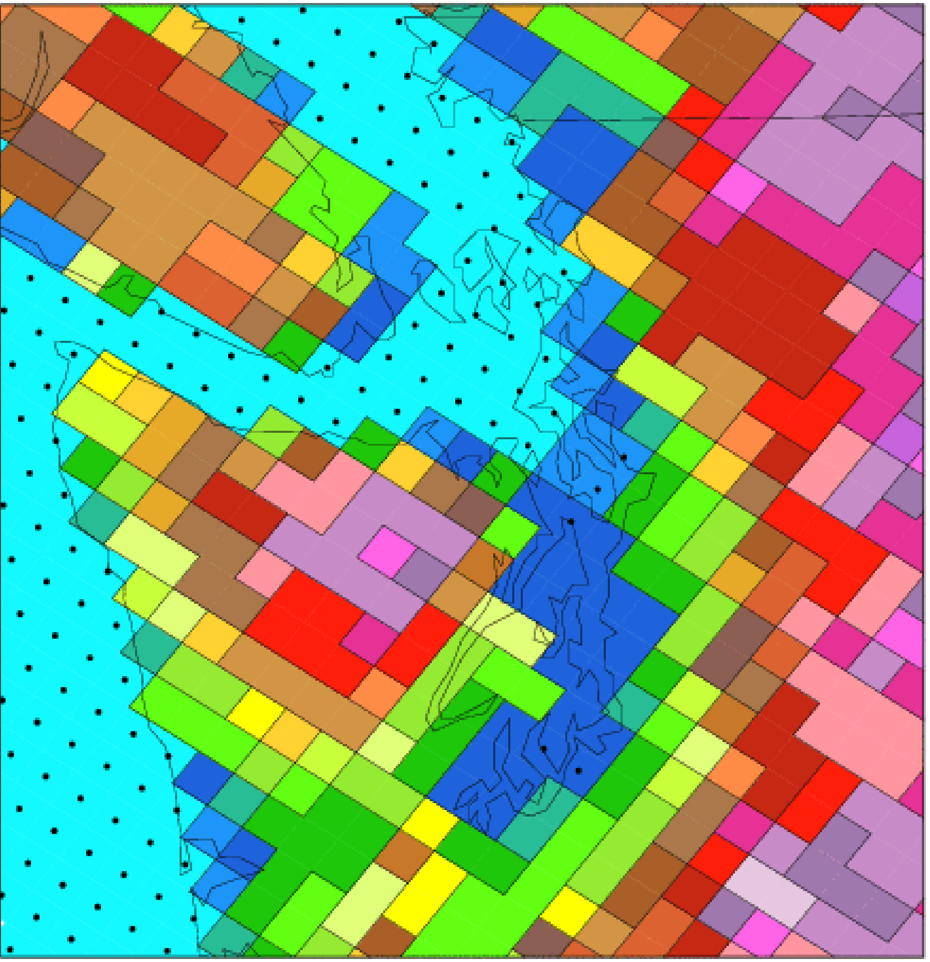


4 km Terrain

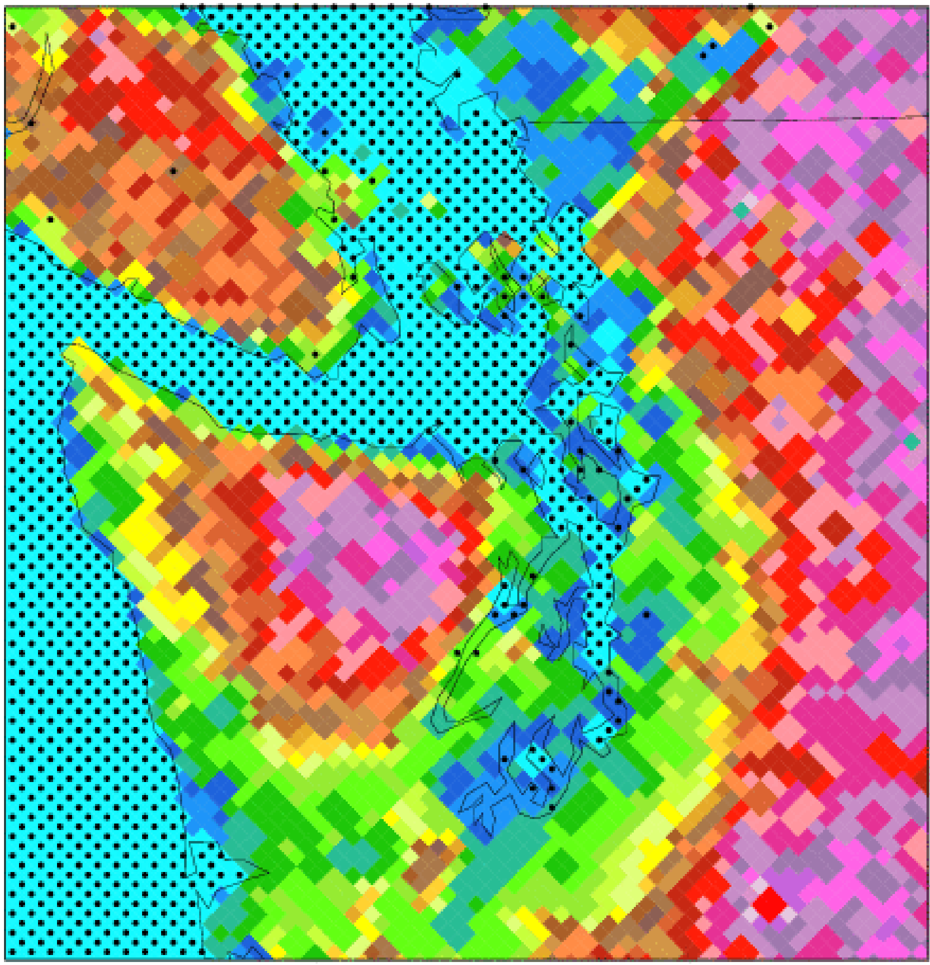


Dots represent water points Domain is Chesapeake Bay

12 km Terrain



4 km Terrain



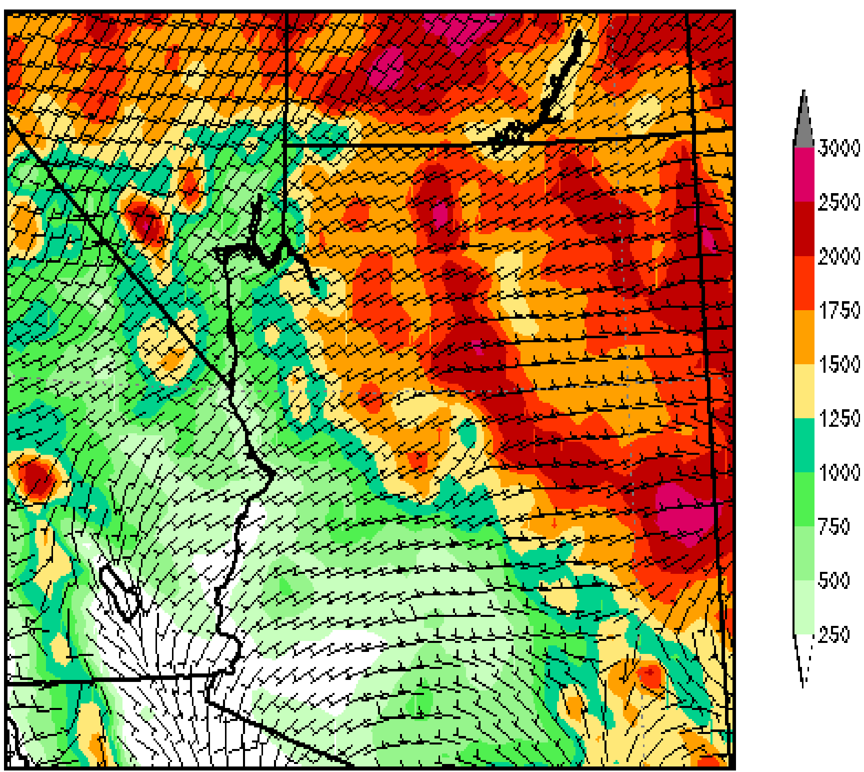
Dots represent water points Domain is Puget Sound

12 km Meso Eta vs 8 km Nest On Web

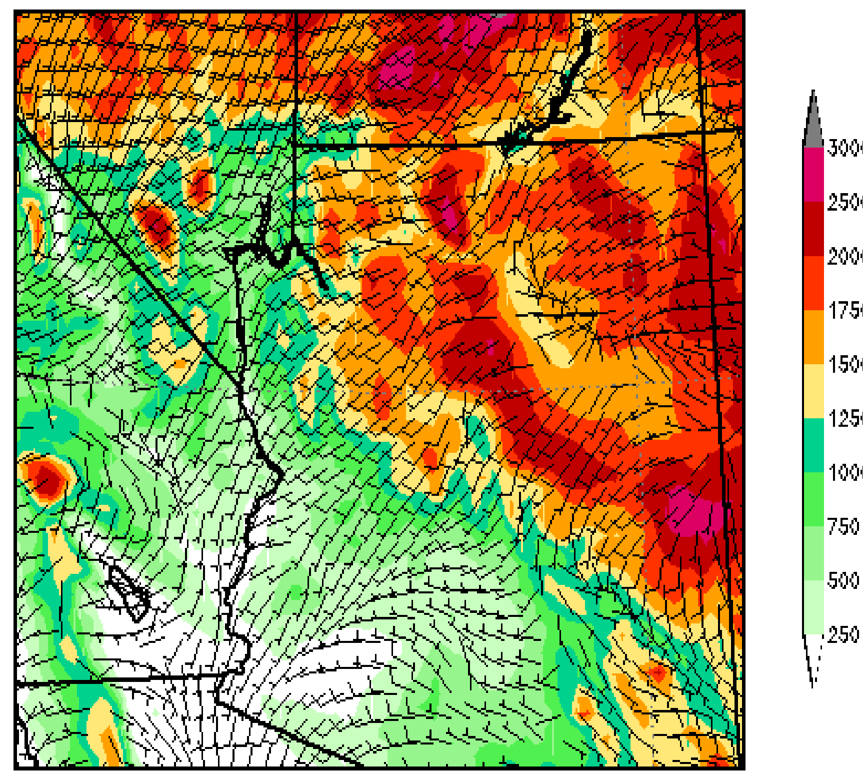
http://wwwt.emc.ncep.noaa.gov/mmb/mmbpll/hiresw.west08/

On left of page, sweep down to localized area options like Arizona & Montana 10 m winds & 2 m temps and (at bottom of the list) the regional 10 m winds covering NW, SW, SF, SLC, and PNW

10-M WND, SFC HGT ETA 42H FCST VALID 00Z 05 SEP 2002



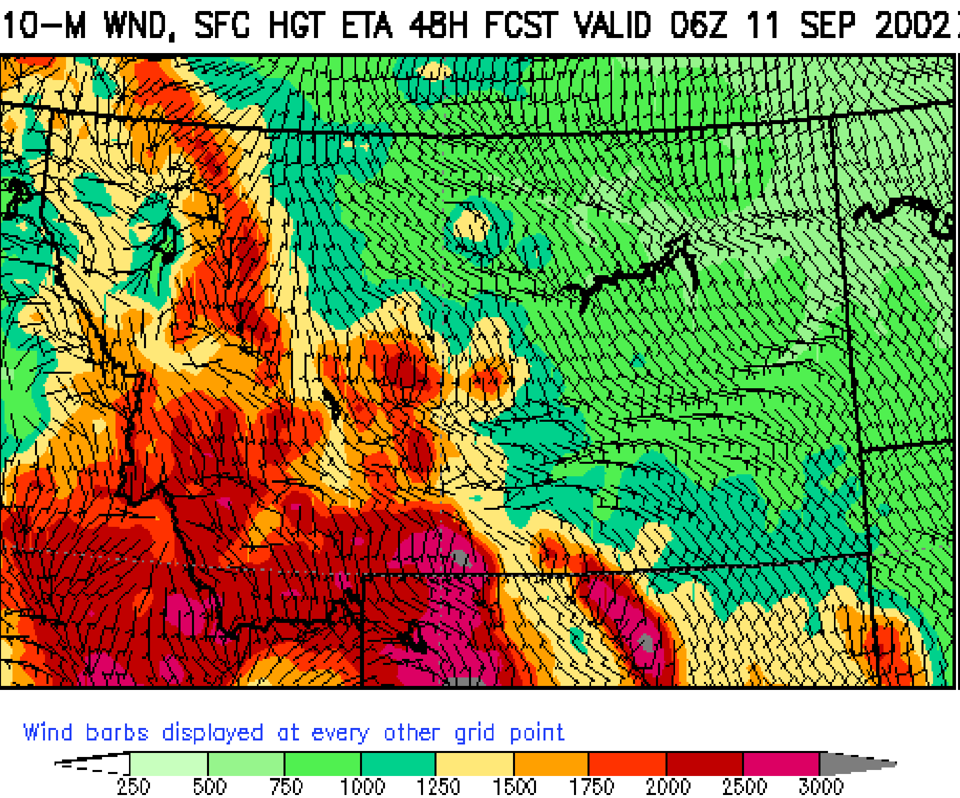
)-M WND, SFC HGT WEST08 42H FCST VALID 00Z 05 SEP 2002

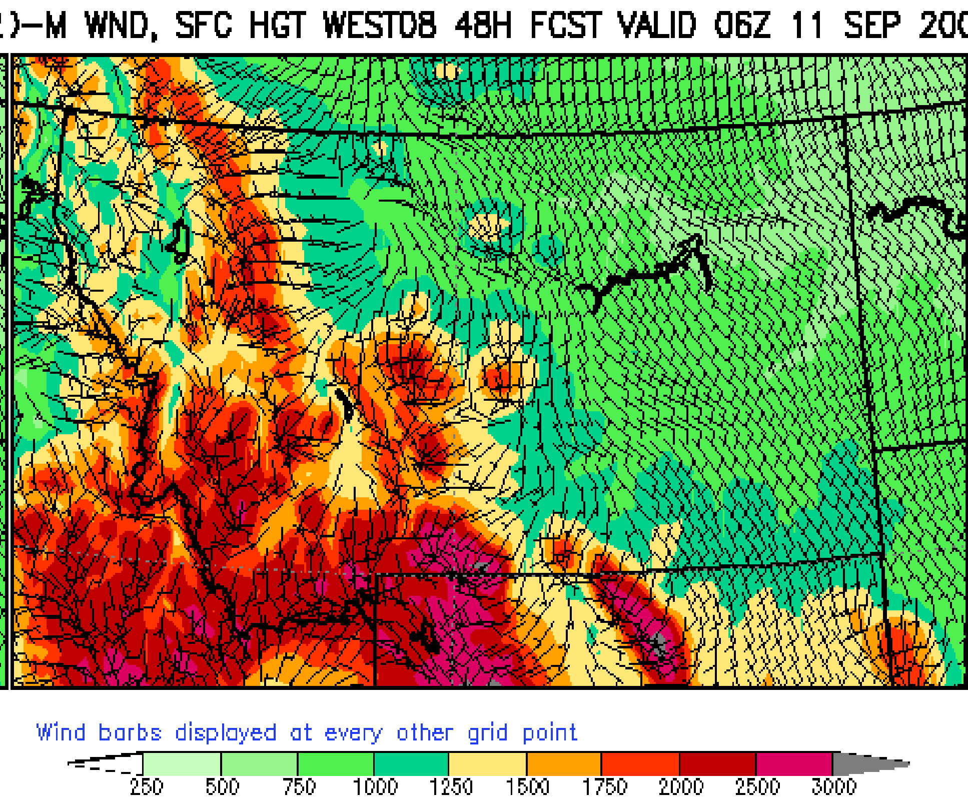


12 km Meso Eta vs 8 km Nest On Web

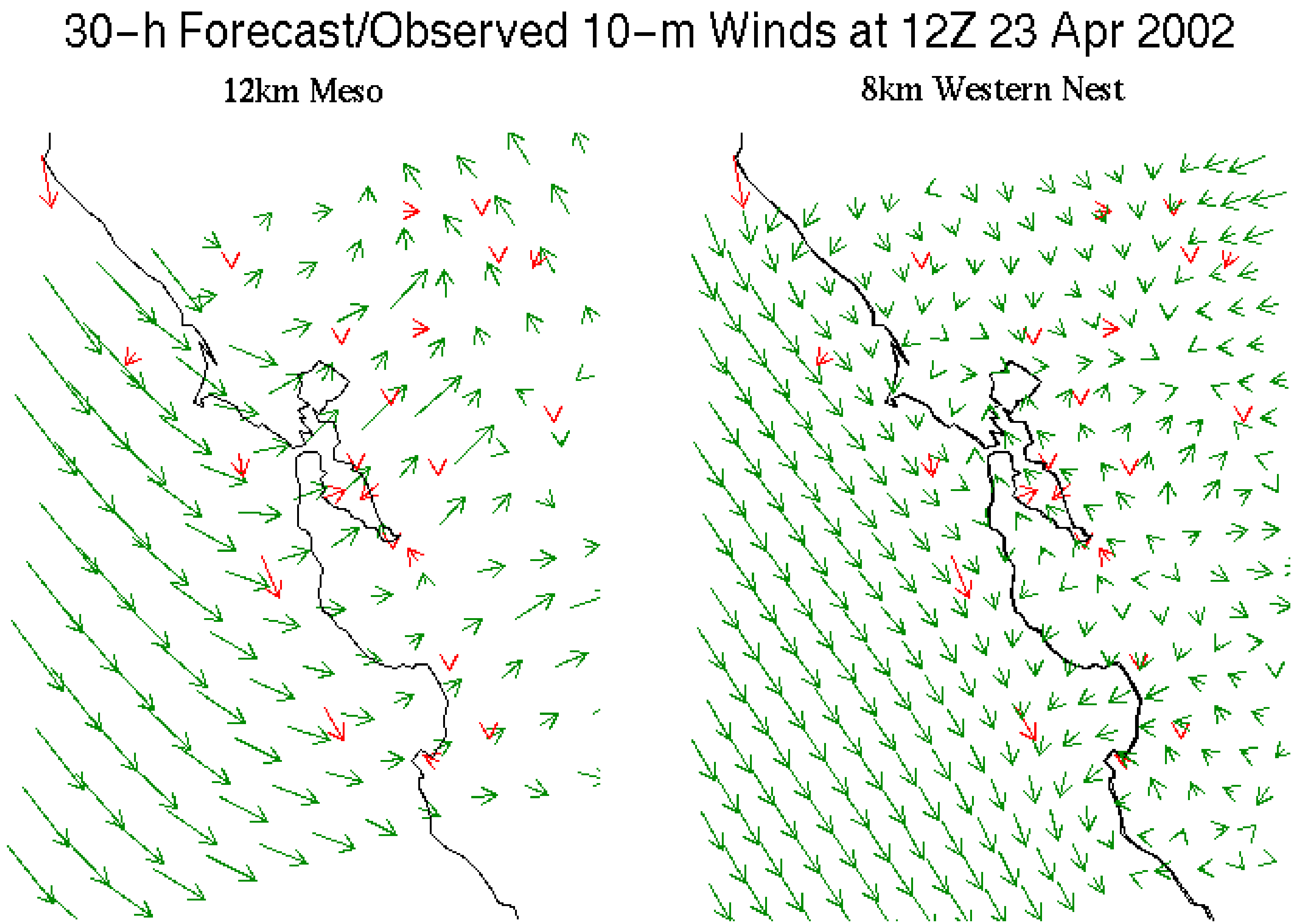
http://wwwt.emc.ncep.noaa.gov/mmb/mmbpll/hiresw.west08/

On left of page, sweep down to localized area options like Arizona & Montana 10 m winds & 2 m temps and (at bottom of the list) the regional 10 m winds covering NW, SW, SF, SLC, and PNW

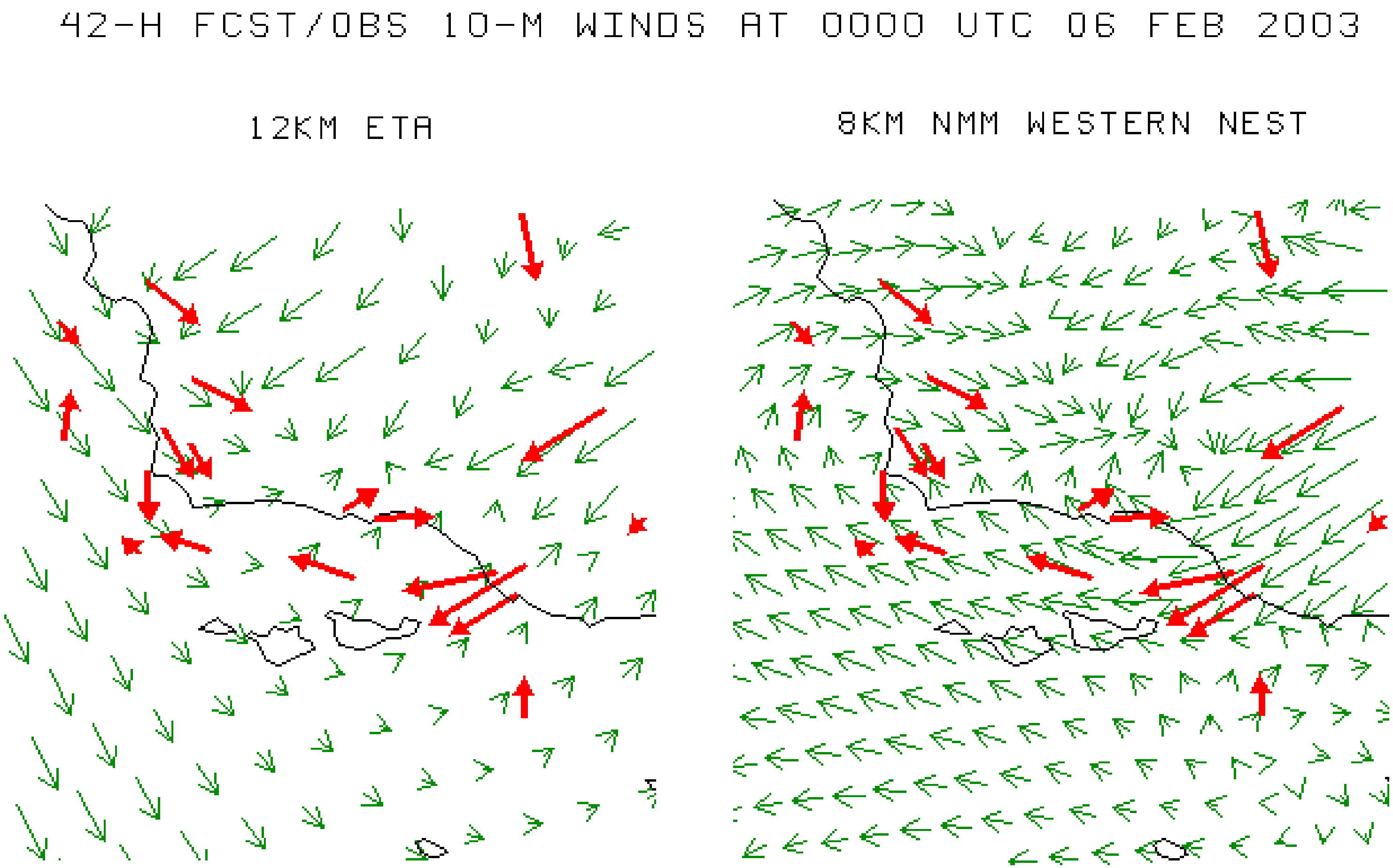




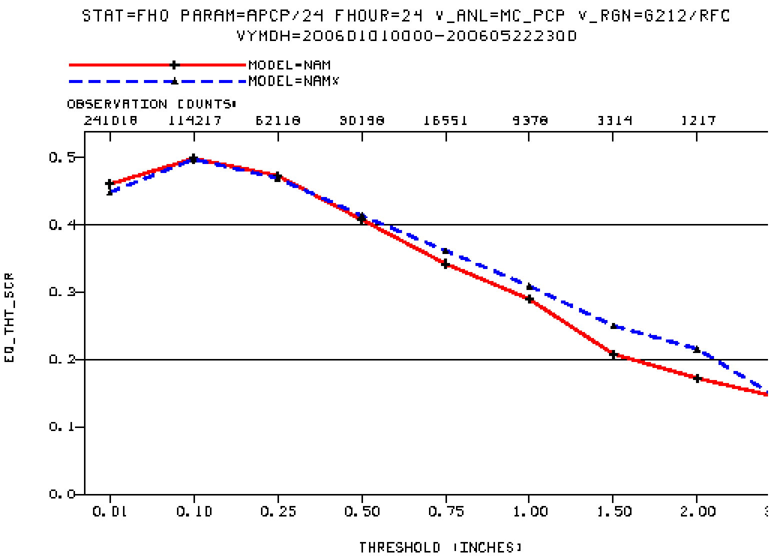
12 km Meso Eta vs 8 km NMM Winds

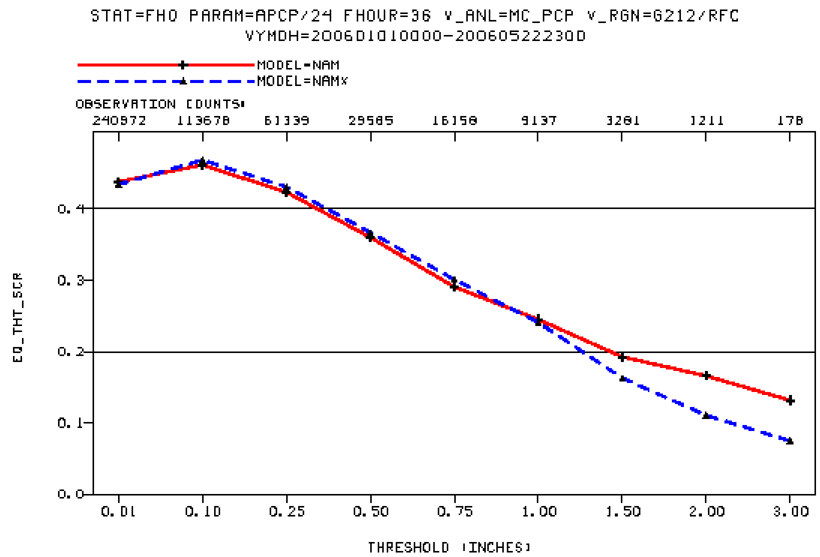


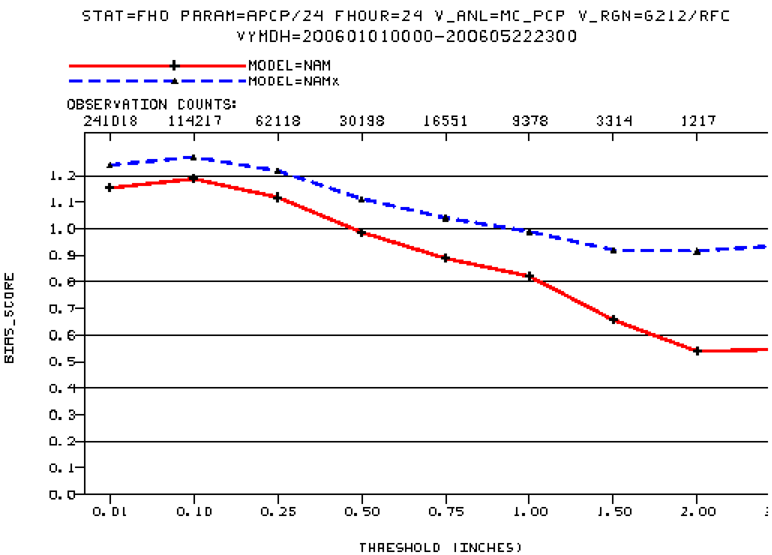
12 km Meso Eta vs 8 km NMM Winds

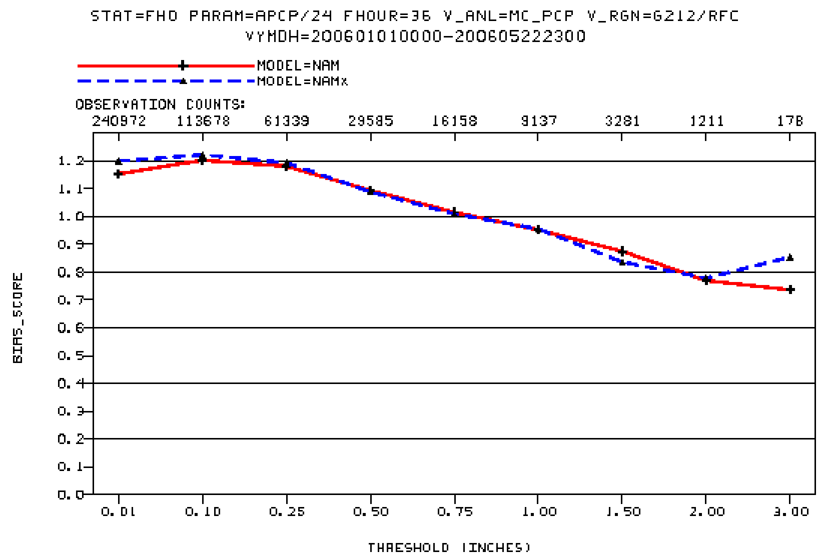


Precip Scores, 2006 1/1 – 5/22, NAM *vs.* NAMX





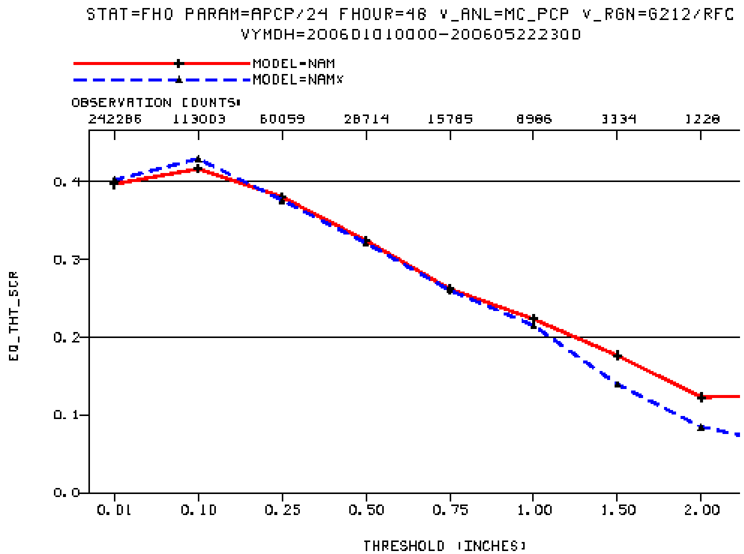


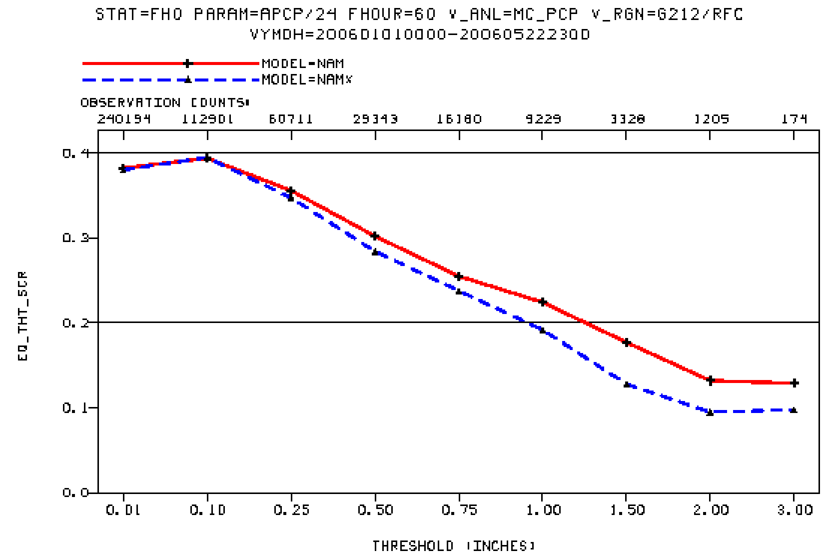


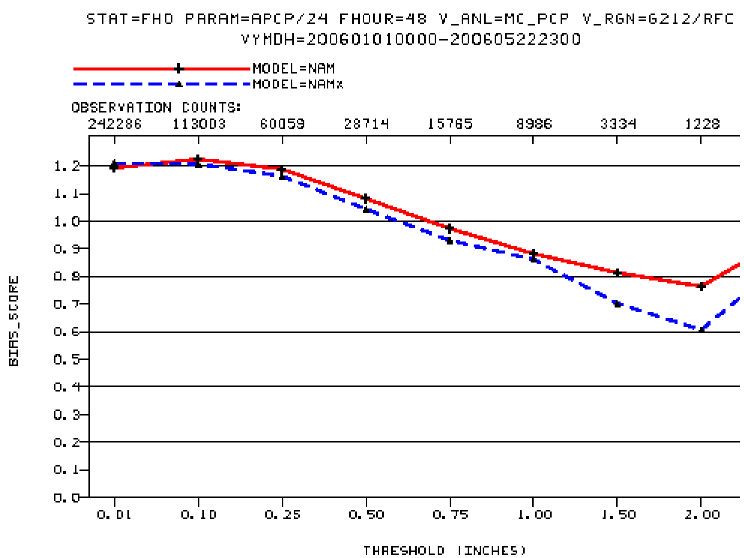
24h forecast

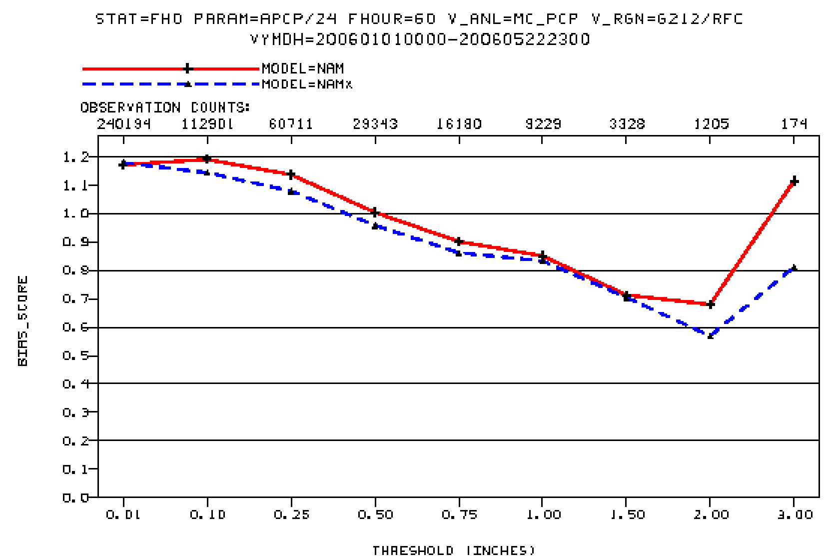
36h forecast

Precip Scores, 2006 1/1 – 5/22, NAM *vs.* NAMX





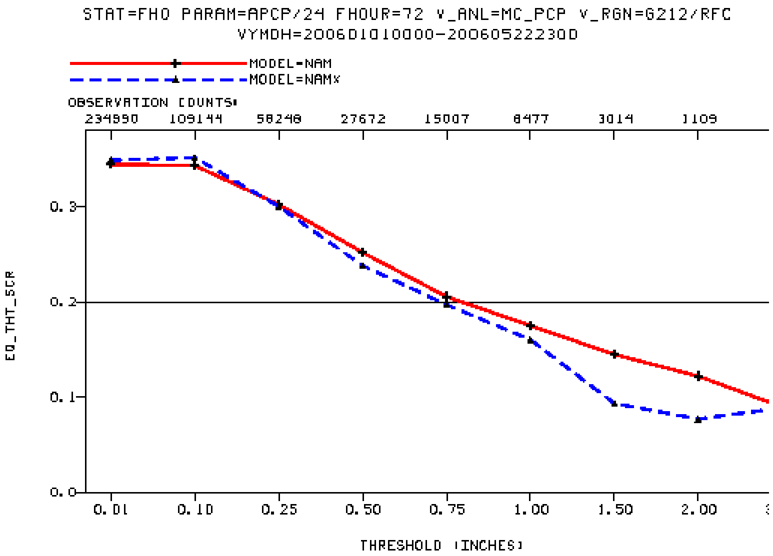


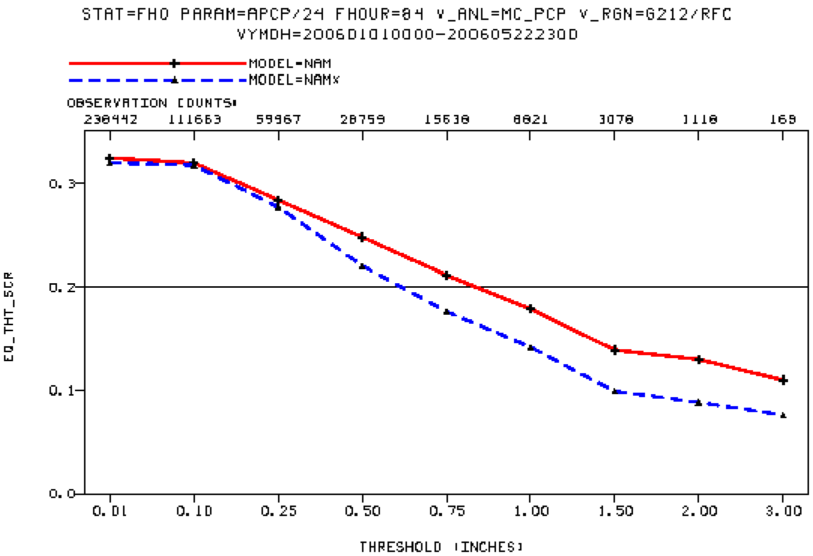


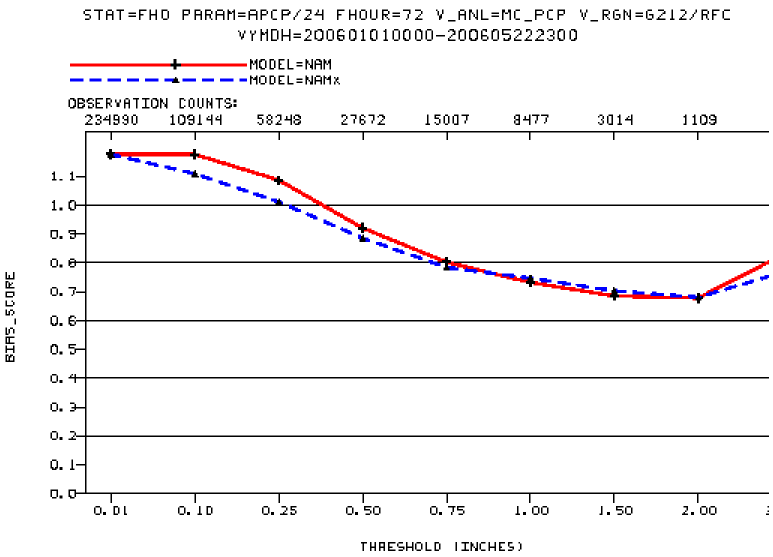
48h forecast

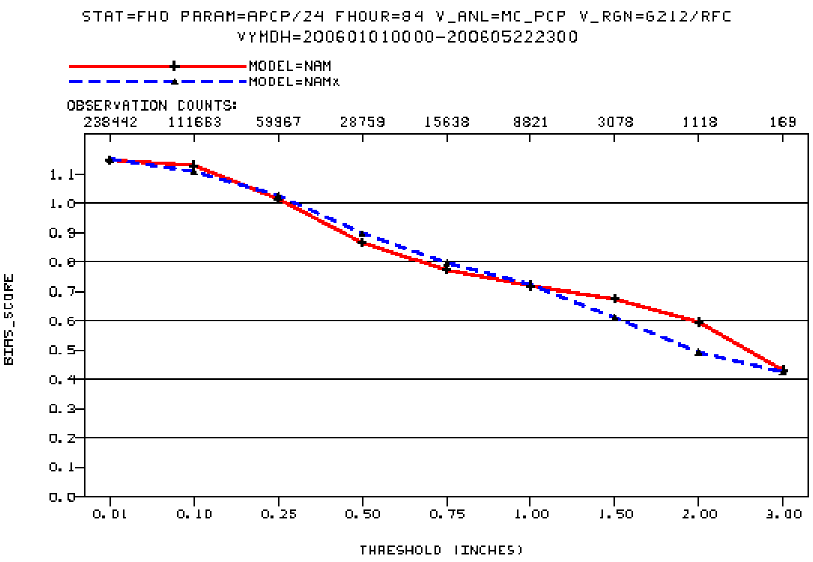
60h forecast

Precip Scores, 2006 1/1 – 5/22, NAM *vs.* NAMX





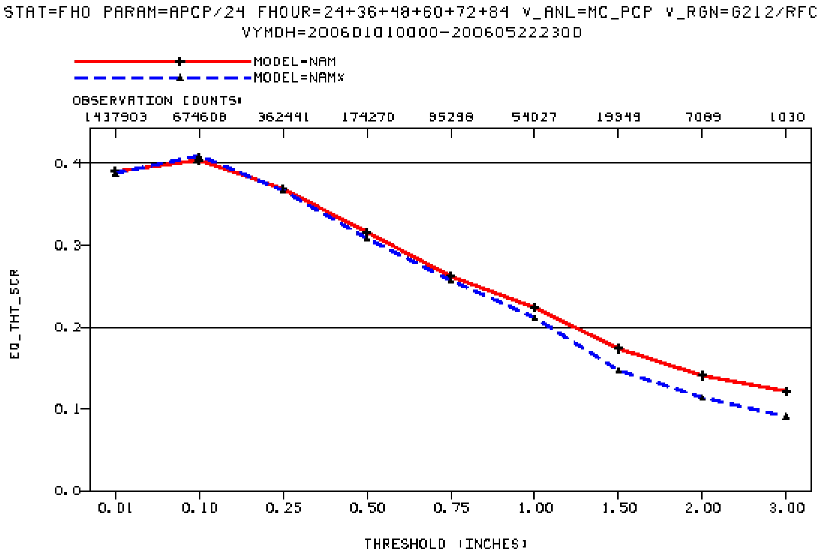


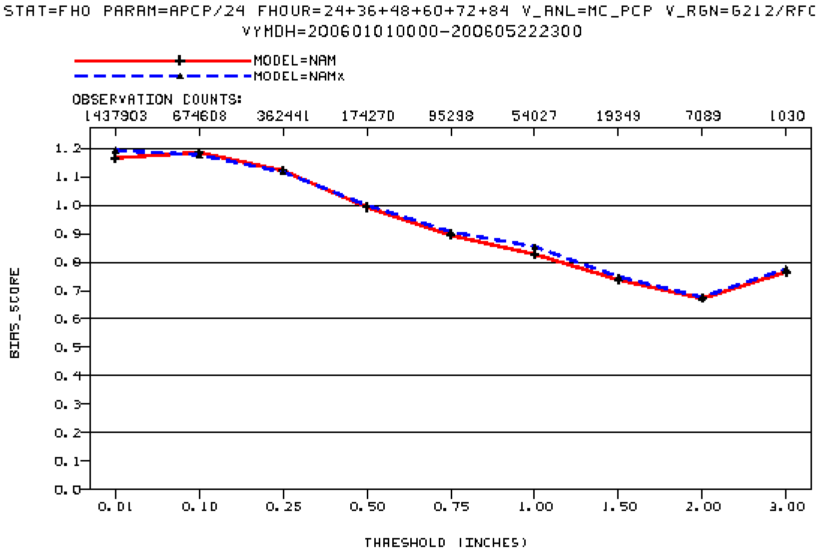


72h forecast

84h forecast

Precip Scores, 2006 1/1 – 5/22, NAM *vs.* NAMX





Combination of 24h/36h/48h/60h/72h/84h forecast periods