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Mesoscale Modeling Branch: Where We Are and Where We're Going

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7 December 2004

Where the Nation's climate and weather services begin

Who We Are

- Government Scientists
  - Tom Black
  - Dennis Keyser
  - Ying Lin
  - Geoff Manikin
  - Jeff McQueen
  - Dave Parrish
  - Eric Rogers
  - Wan-Shu Wu
- Visiting Scientists
  - Mike Ek
  - Zavisa Janjic
  - Fedor Mesinger
- Contractor Scientists
  - Sajal Kar
- Contractor Scientists
  - Nashat Ahmad
  - Mike Baker
  - Stacie Bender
  - Hui-Ya Chuang
  - Jun Du
  - Brad Ferrier
  - S. Gopalakrishnan
  - Dusan Jovic
  - Pius Lee
  - Curtis Marshall
  - Manuel Pondeca
  - Jim Purser
  - Matt Pyle
  - Perry Shafran
  - Marina Tsidulko
  - Binbin Zhou

TOPICS

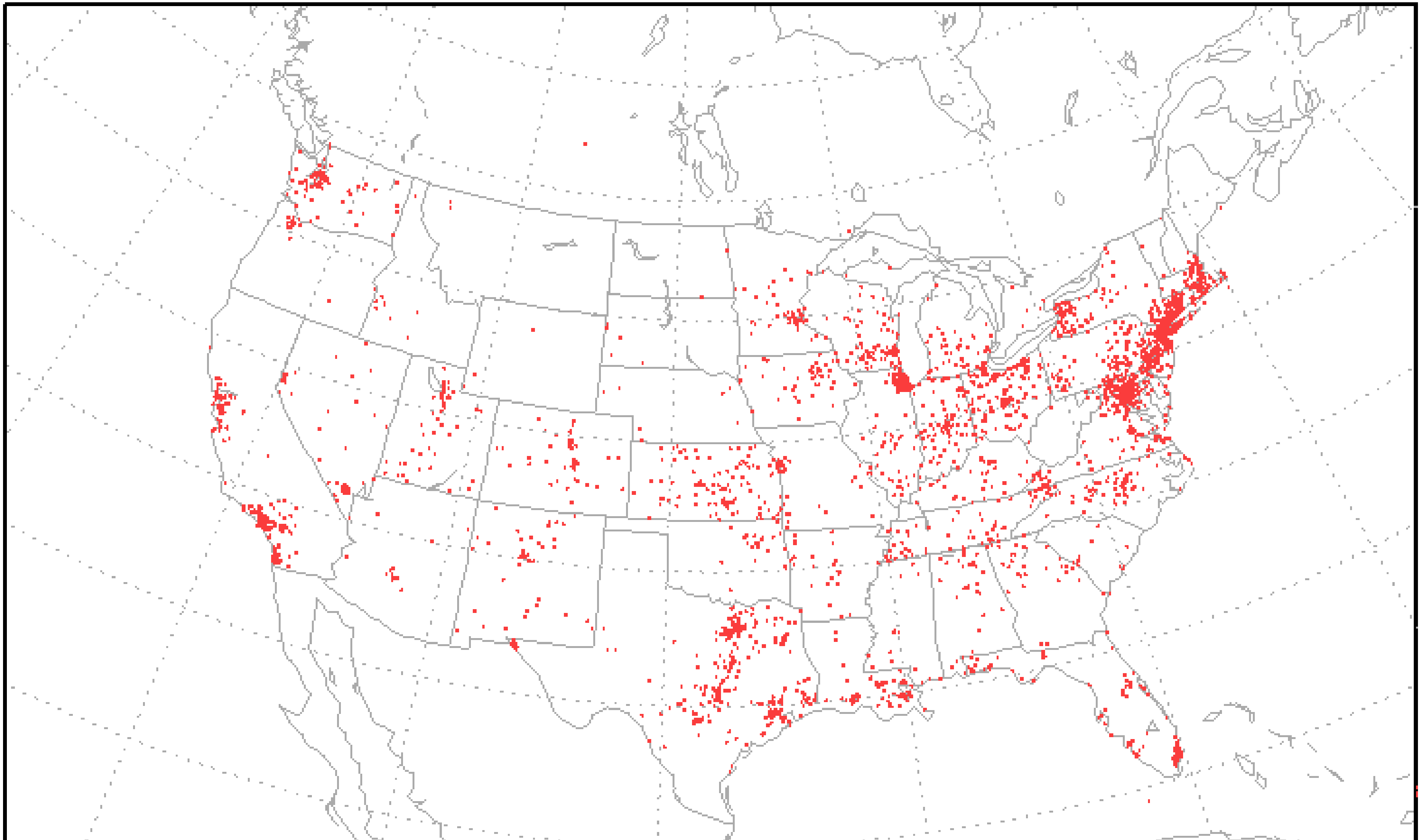
- Recent Changes in Operations
  - Observation Processing in 2004
  - Eta “Winter” Upgrade package - March
  - DGEX (Downscaled GFS by Eta Extension) April+June
  - Fire Weather / IMET Support using NMM
  - SPC / NSSL Spring Program runs of WRF-NMM
  - SREF Upgrade – 17 August
  - WRF in HiResWindow – 21 September
- Development & Other Highlights
  - Air Quality Forecast System – 17 September
  - North American Regional Reanalysis
- Plans for the Future [most interspersed above]
  - Final Eta Upgrade Package
  - Real Time Mesoscale Analysis
  - North American Mesoscale WRF-NMM

Observation Processing in 2004

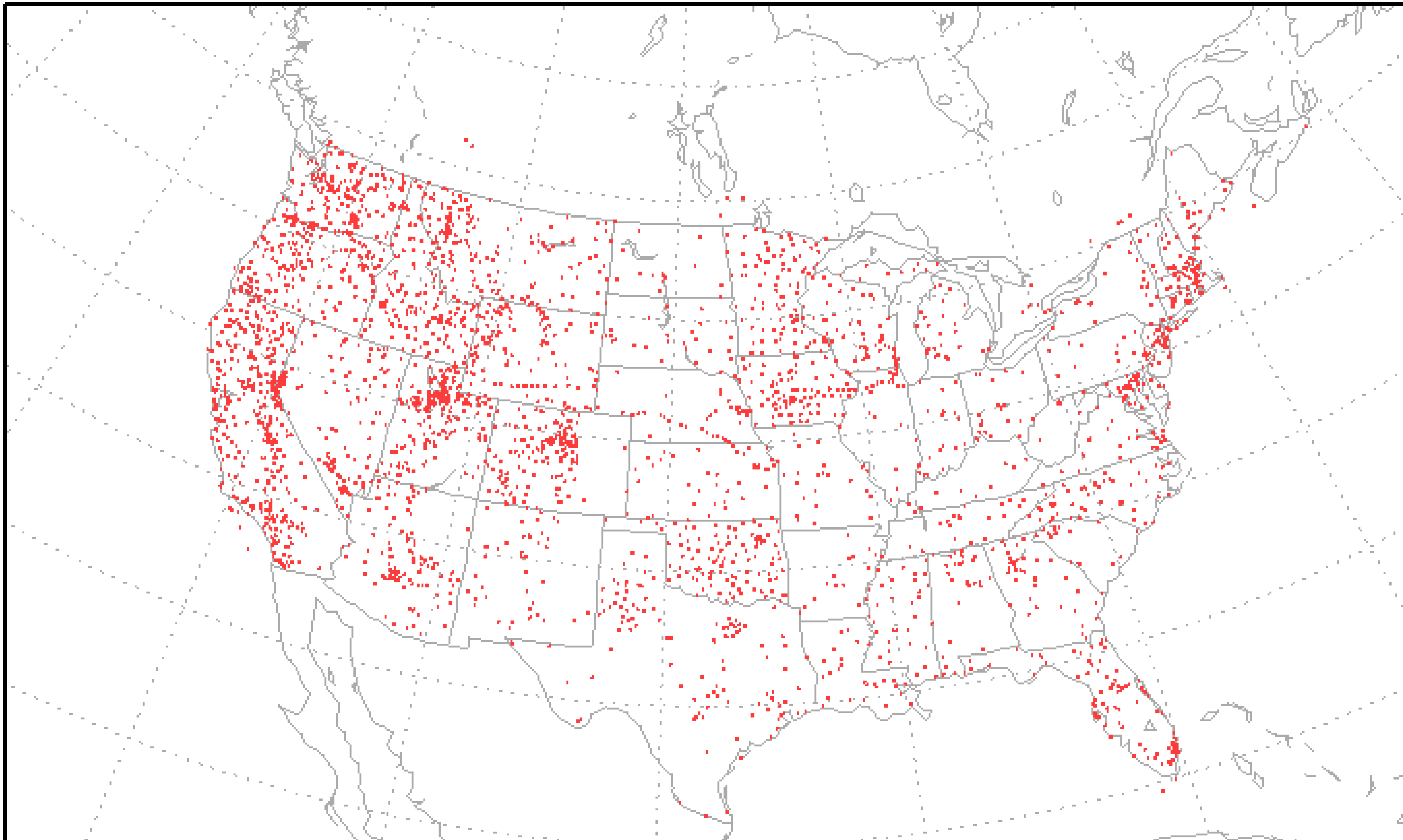
this is only a small fraction of the year's activities

- Feb Implemented new BUFRLIB
- Feb Eliminated early RUC analysis at 00z & 12z and Fixed radar dup check for 88D radar winds
- Mar Fixed Aerosol, ozone, snow & sst processing
- Apr CRISIS eliminate virtual temp error above tropopause
- Apr CDAS processing & editbufr
- May 4 Fixed ITMI & ISND
- May AWS mesonet data stop due to MOU expiration
- Jul Implemented processing of 88D Level 2.5 radial winds
- Jun Fixed Tropical Cyclone vitals processing
- Jun Sat ingest monitoring webpage
- August
- Sep 13 Release of AIRNOW prepbufr job
- Oct AWS mesonet data begin to arrive again
- TBD Move BUFR Mnemonic Table to fixed-field
- Nov 16 15z CRISIS-fixed duplicate checker for marine data

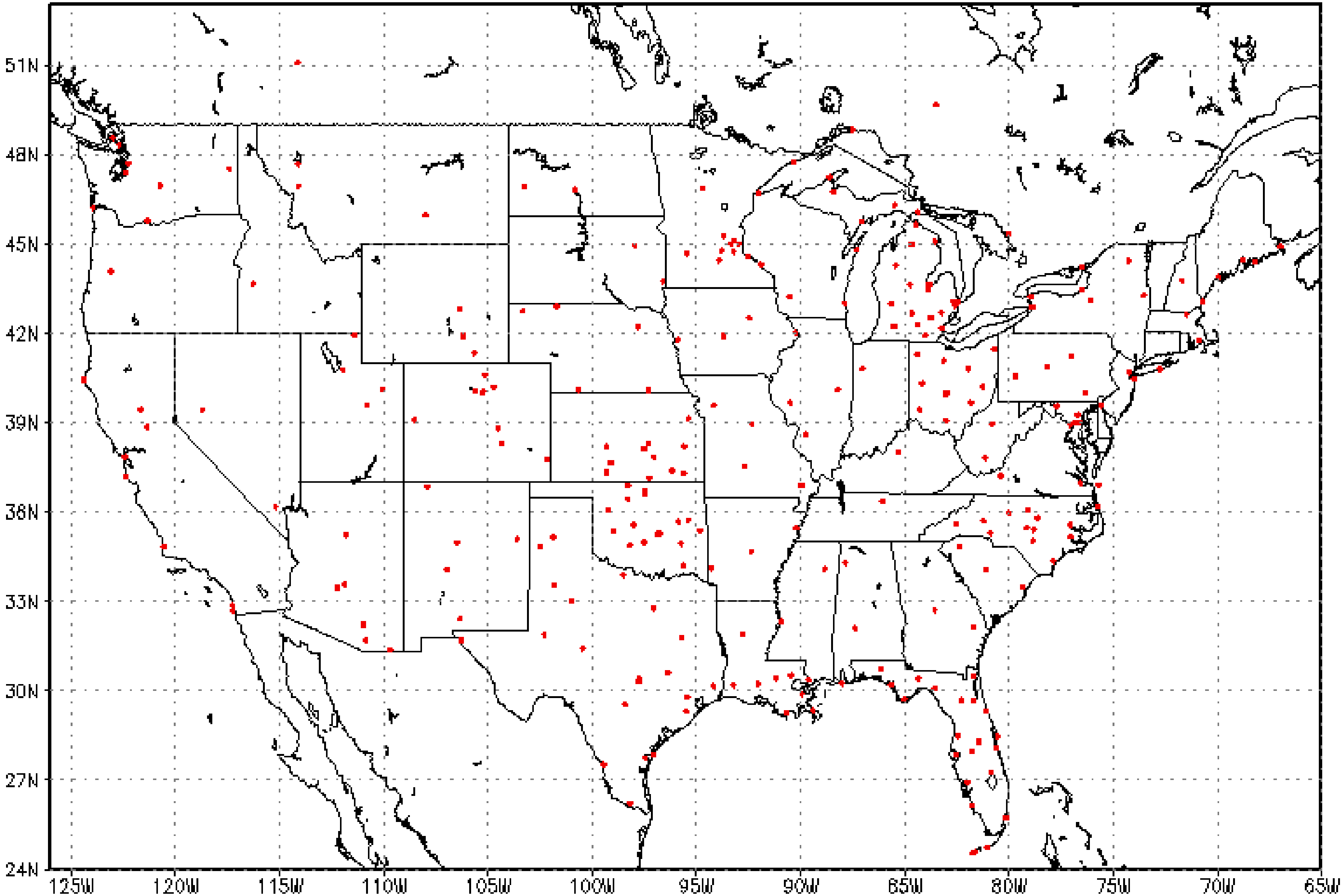
AWS Mesonet Obs 10 Nov 04 00z



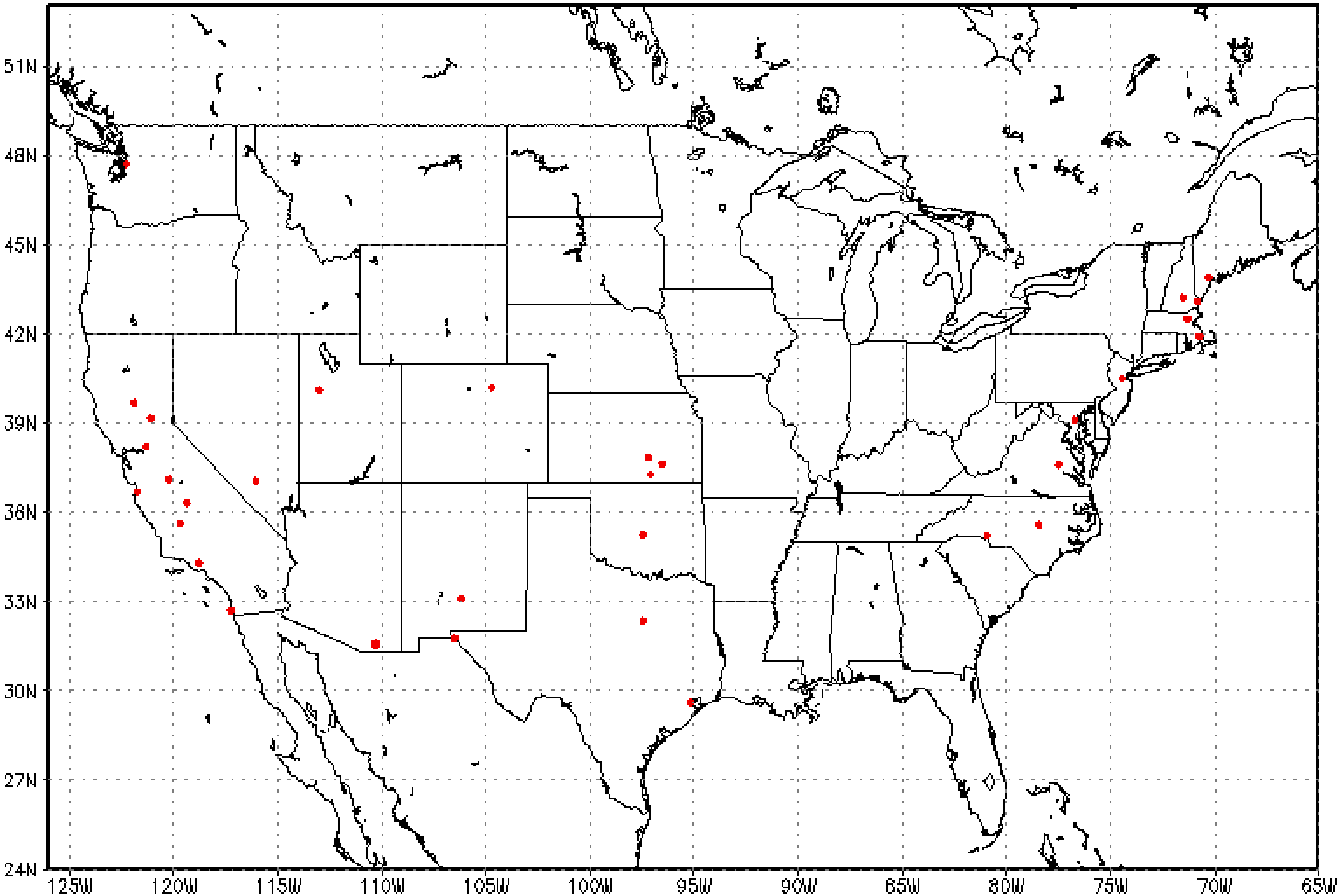
Non-AWS Mesonet Obs 10 Nov 04 00z



GPS IPW (Integrated Precipitable Water) Ob Density



Boundary Layer Profiler Ob Density



How are PIREPs used?

- Two conditions must be met for use of a PIREP in NCEP’s data assimilation system
    - Temp, wind +/or moisture are reported and
    - They are observed by sensors
- However, PIREPs are used extensively by AWC for validation of turbulence and icing using FSL’s RTVS
- Current PIREP ob counts are small: ~600 per day versus >100,000 other aircraft

Non-Satellite Data Used in GDAS

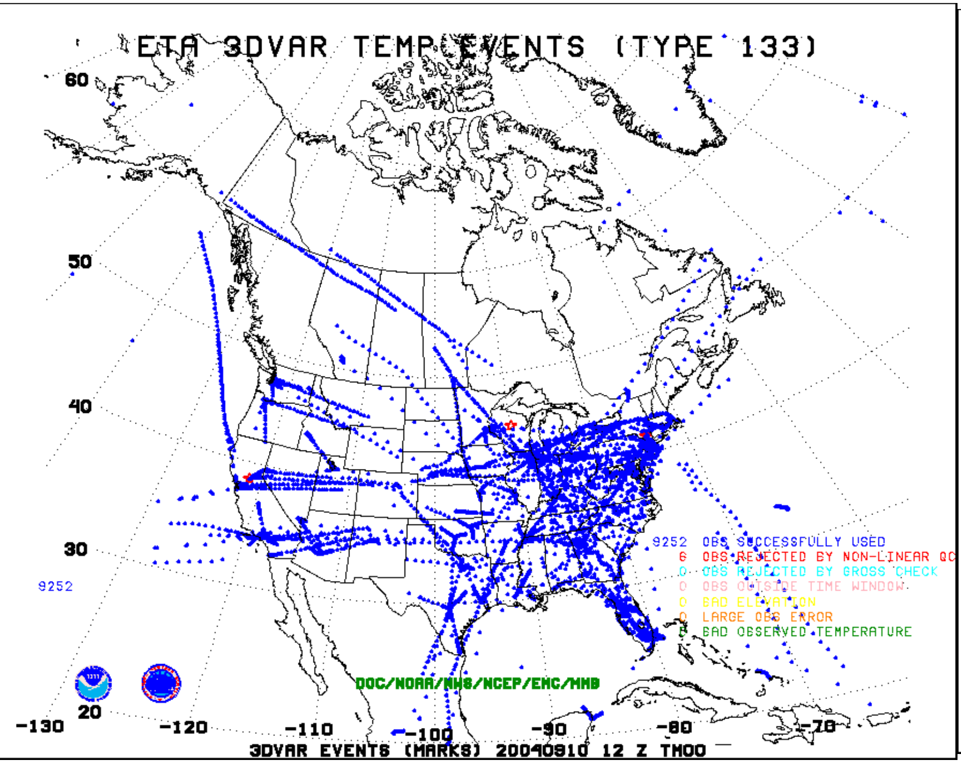
Bookmarks Location: http://www.nco.ncep.noaa.gov/dmqab/counts/August_2004.html What's Rela

AUGUST 2004 GDAS DATA DUMPS

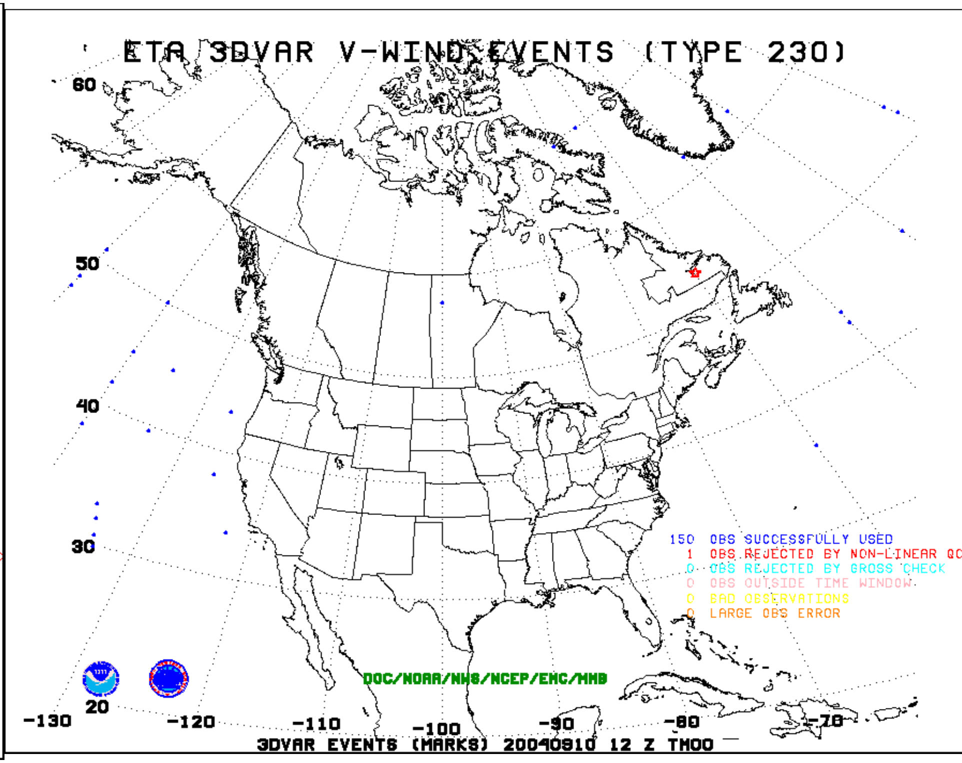
Category	Subcategory	T00Z	T06Z	T12Z	T18Z	Total Number	Total Input	% Input
Land Sfc	Synoptic	14742	14993	15205	14778	59718	59718	*
*	METAR	29196	30554	32630	31444	123824	123824	*
*	sub-total	43938	45547	47835	46222	183542	183542	1.5446458
Marine Sfc	Ship	732	732	726	717	2907	2907	*
*	Drifting Buoy	3511	3131	3417	3250	13309	13309	*
*	Moored Buoy	1142	1143	1143	1144	4572	4572	*
*	CMAN	482	477	476	484	1919	1919	*
*	Tide Gauge	709	640	765	652	2766	2766	*
*	MSLP Bogus**	299	0	305	0	604	*	*
*	sub-total	6576	6123	6527	6247	25473	25473	0.2143747
Land Soundings	Fixed Land RAOB	625	95	620	76	1416	1416	*
*	Mobile Land RAOB	2	1	2	1	6	6	*
*	Ship RAOB	3	2	6	2	13	13	*
*	Dropsonde	5	2	4	5	16	16	*
*	Pibal	69	96	79	50	294	294	*
*	Profiler	232	229	229	235	925	925	*
*	NEXRAD Wind	1719	1722	1698	1686	6825	6825	*
*	sub-total	2655	2147	2638	2055	9495	9495	0.0799077
Aircraft	AIREP	996	930	903	1039	3868	3868	*
*	PIREP	159	24	139	274	596	596	*
*	AMDAR	2092	4357	4851	4139	15439	15439	*
*	ACARS	25502	15245	20454	24297	85498	85498	*
*	RECCO	5	2	4	8	19	19	*
*	sub-total	28754	20558	26351	29757	105420	105420	0.8871896
Total	non-satellite	81923	74375	83351	84281	323930	323930	2.7261178

Aircraft Observation Density

Current ACARS temp reports

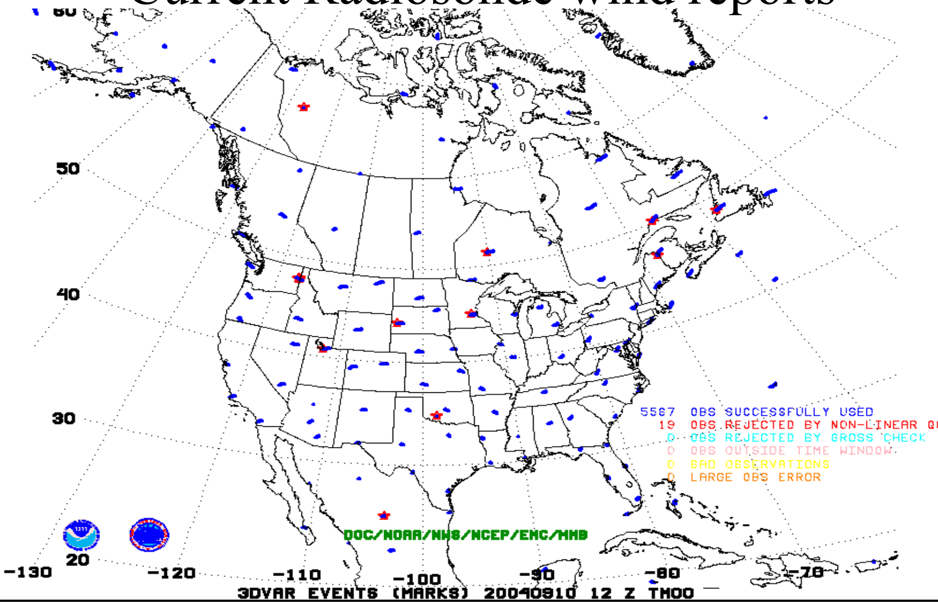


Current AIREP+PIREP wind reports

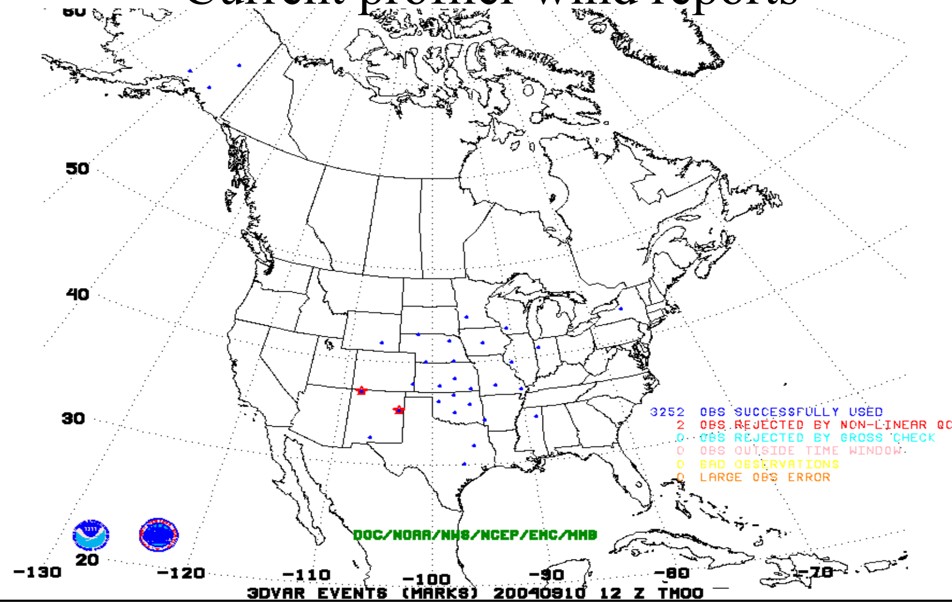


Upper-Air Observation Density

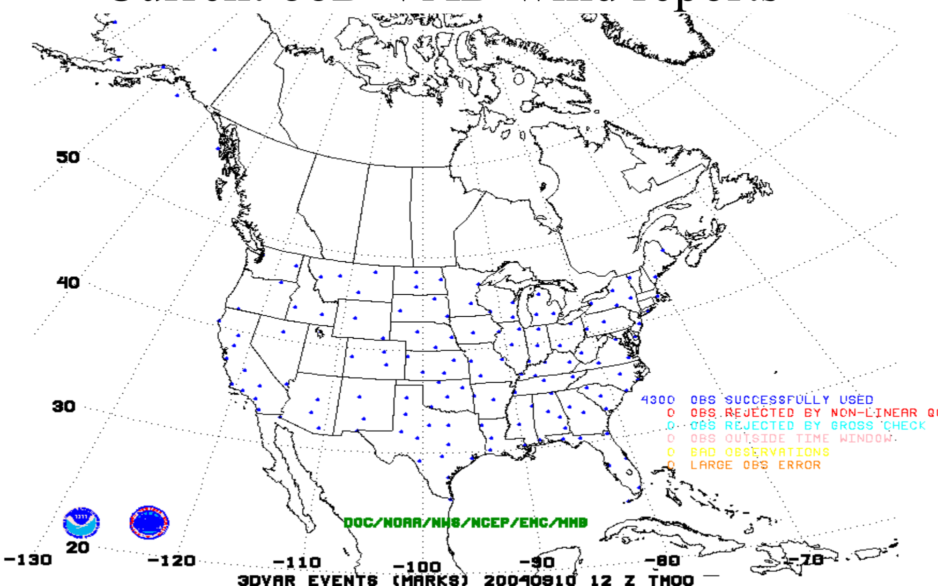
Current Radiosonde wind reports



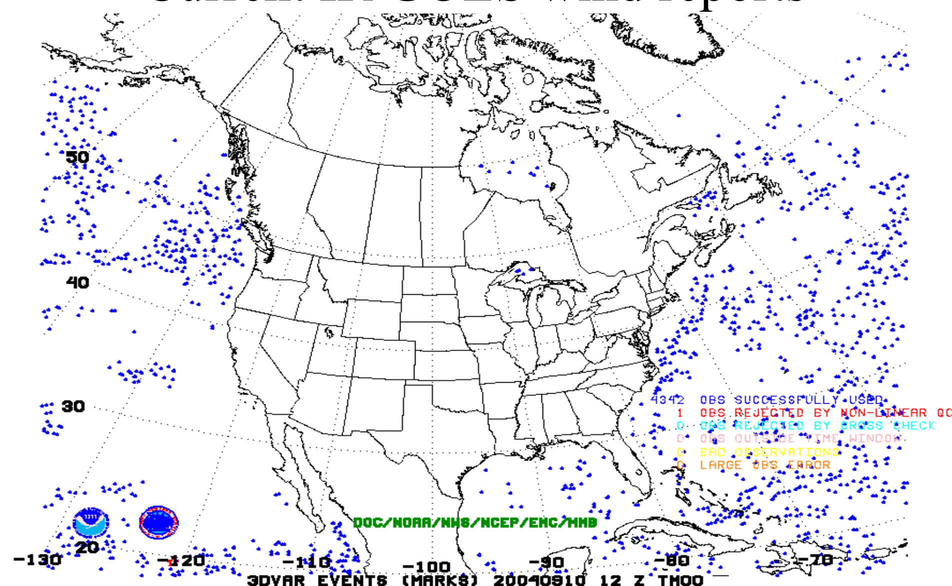
Current profiler wind reports



Current 88D VAD wind reports

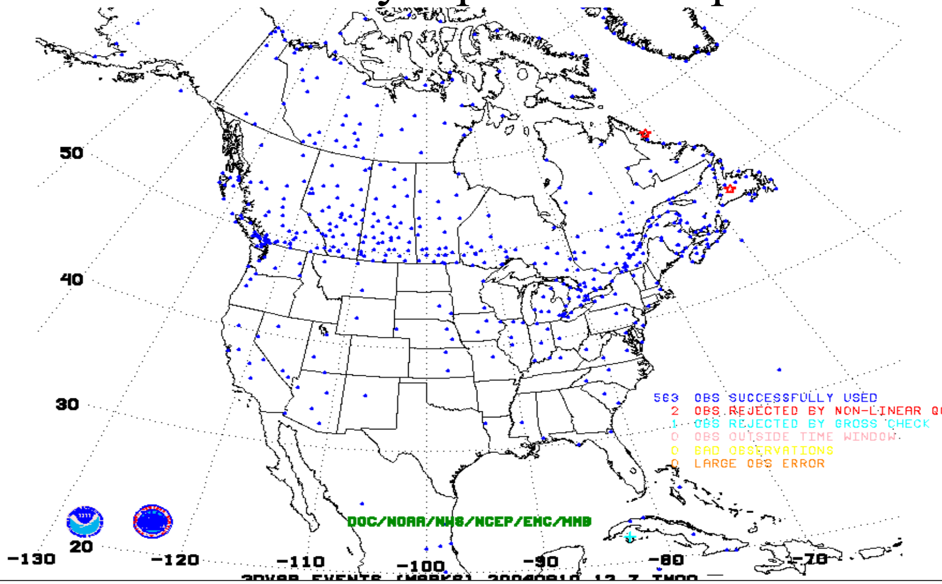


Current IR GOES wind reports

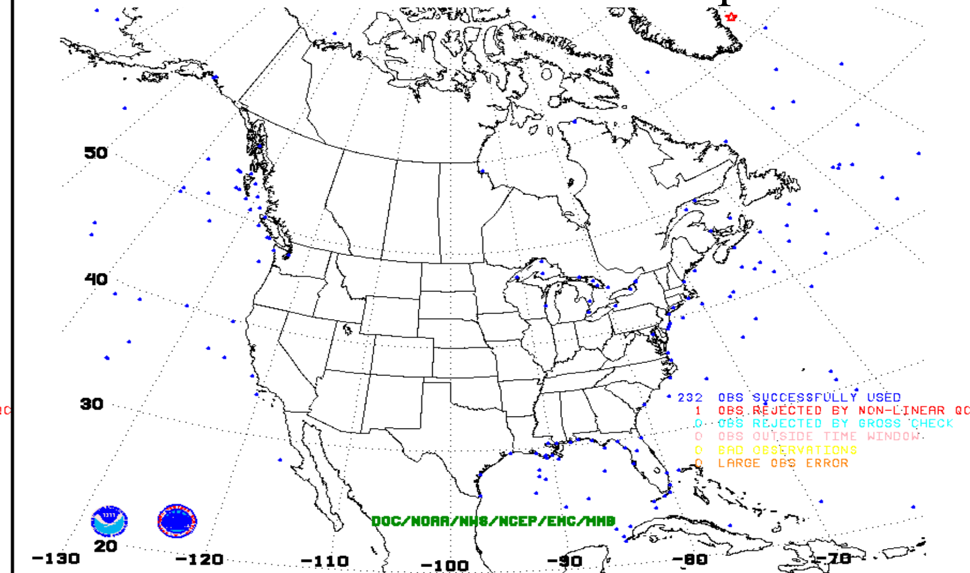


Surface Observation Density

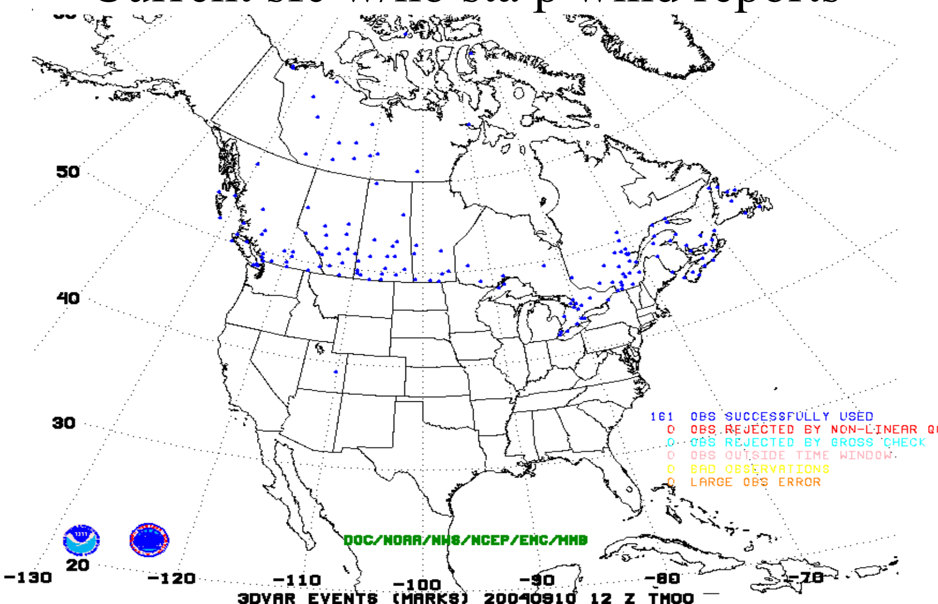
Current sfc synoptic wind reports



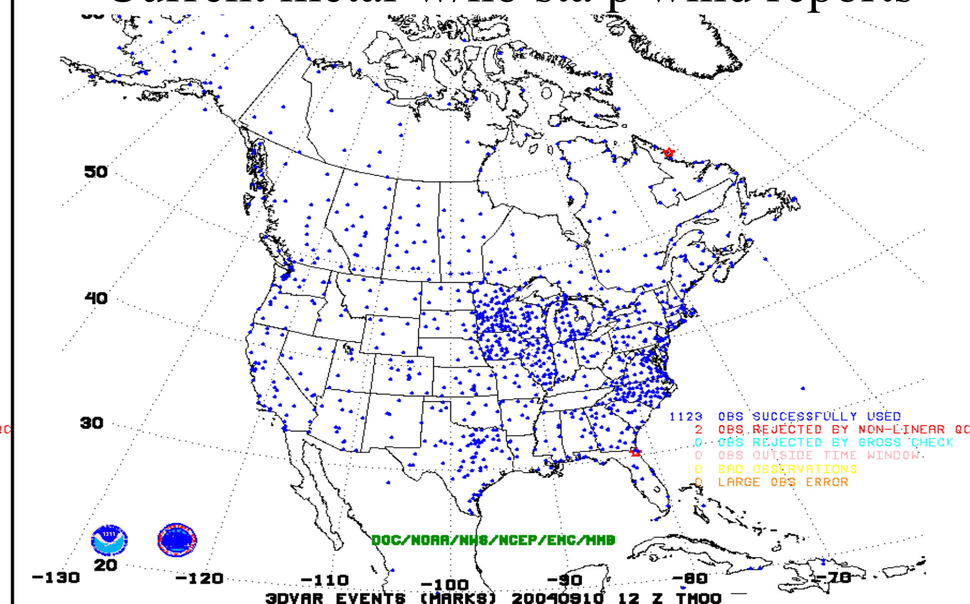
Current sfc marine wind reports



Current sfc w/no sta p wind reports



Current metar w/no sta p wind reports



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Operational Implementation of Winter 2004 Meso Eta Change Package

Geoff DiMego & Eric Rogers

10 March 2004

http://wwwt.emc.ncep.noaa.gov/mmb/briefings/EtaWinter2004.briefing.html

Where the Nation’s climate and weather services begin

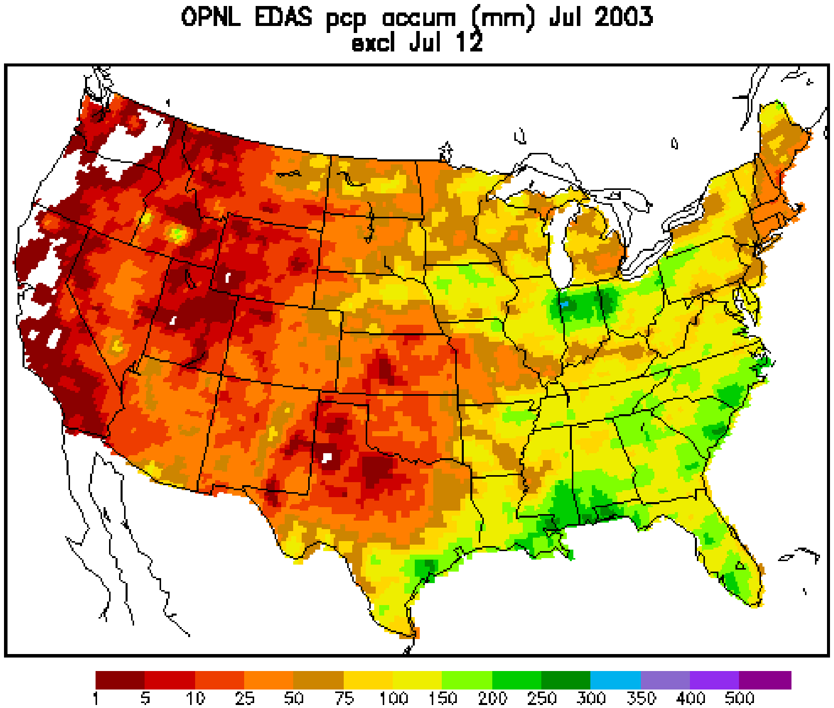
Contents of Eta Winter 2004 Bundle

- Precip Assimilation change
  - Use of daily gauge data for bias adjustment of multi-sensor precipitation analyses input to the EDAS
- 3DVAR analysis changes
  - Assimilate GOES-12 radiances
  - More efficient code using less memory
- Eta model / post-processor changes
  - Feed fraction of frozen precip from Ferrier microphysics into land-surface model
  - Fixed radiation driver for downward LW fluxes in presence of fog
  - Fixed ½ hour error in zenith angle used to posted Eta solar fluxes
- Output / Diagnostic changes
  - Add eddy diffusivity to Eta output file on AQ model sigma surfaces for CMAQ (Ozone/Air Quality)

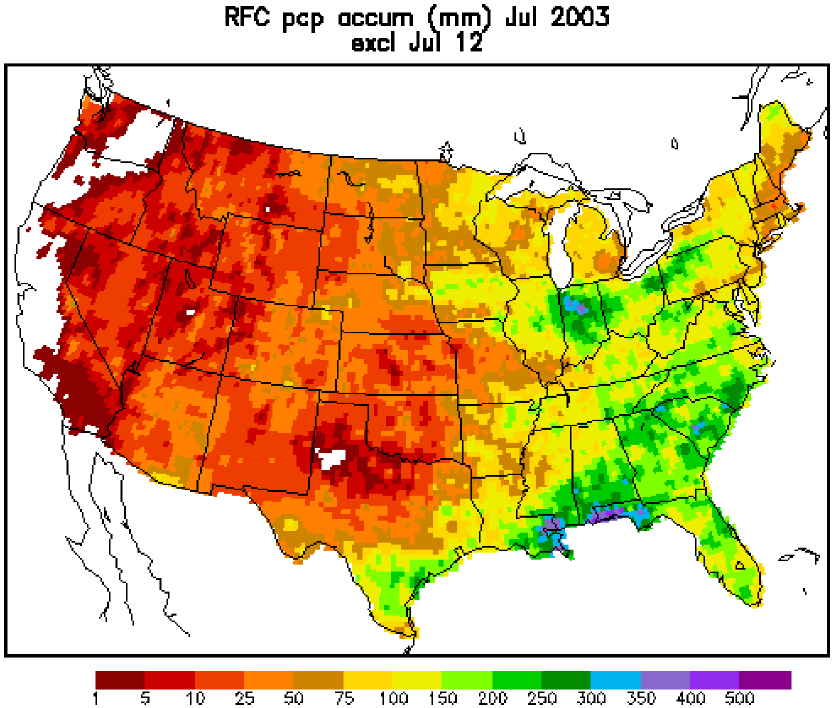
Improving Precipitation Assimilation

Hourly multi-sensor (radar+gauges) precip analysis used as input for Eta/EDAS precipitation assimilation tends to have a low bias, leading to drier soil:

July 2003 Total Rainfall

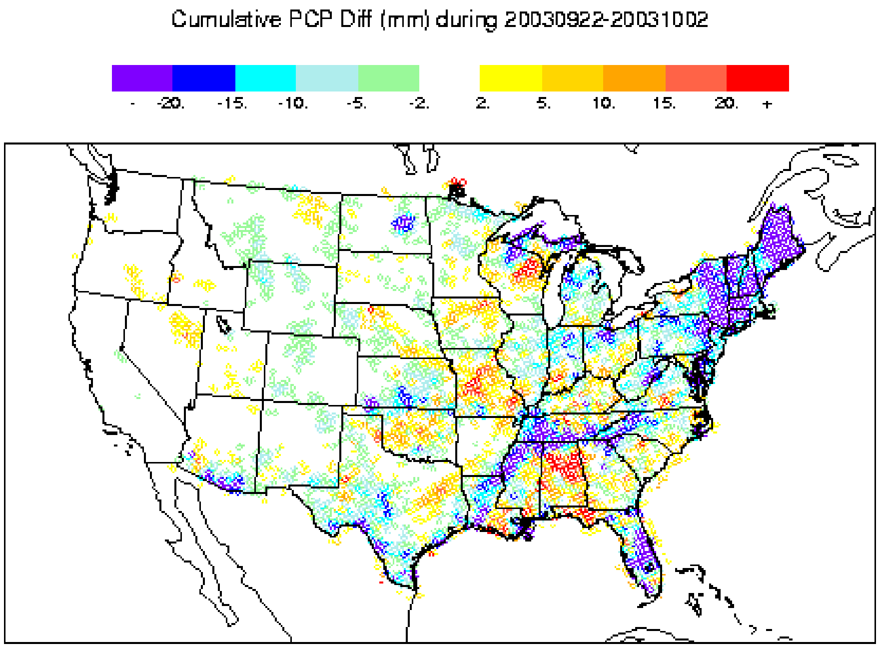


In EDAS (deficient)



From Daily Gauge analysis

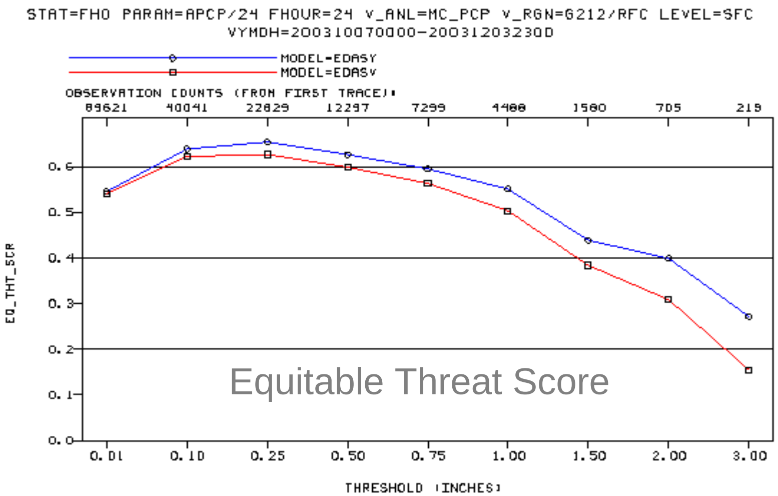
Bias Adjustment of Hourly Analyses for EDAS

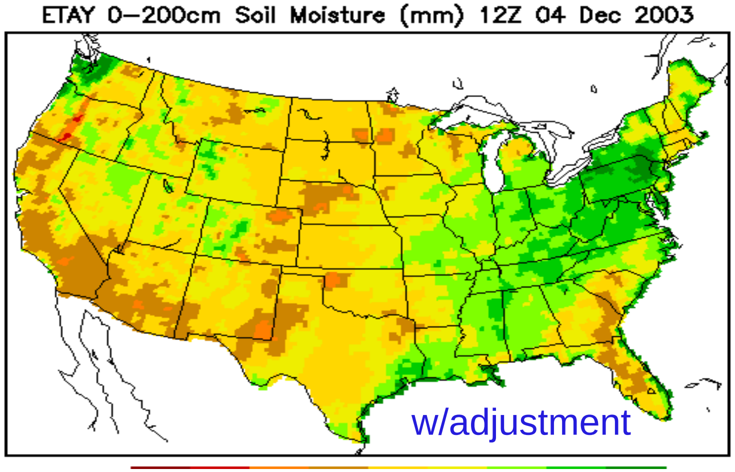


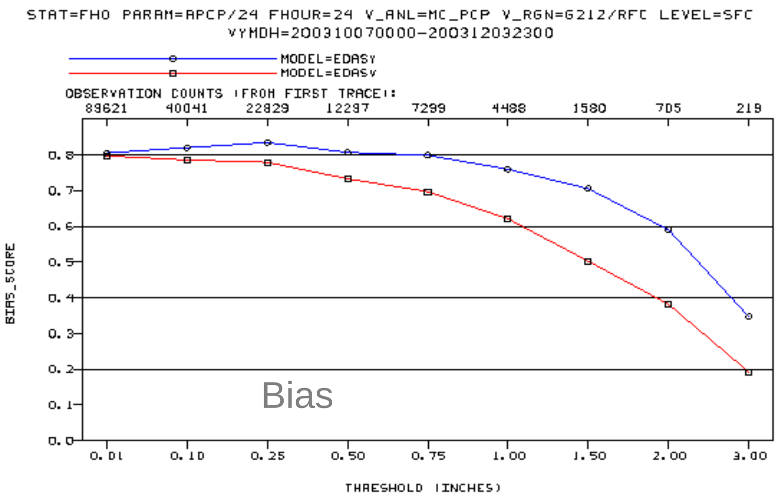
1. Each day, compare 24h EDAS precip (12Z-12Z) to daily gauge analysis
2. Add the difference to a precipitation budget history file
3. Use the <u>budget history file</u> to adjust hourly precip input. Goal: to 'pay off the debt' in 1 day. Limit of adjustment: +/- 20% of pre-adjustment total

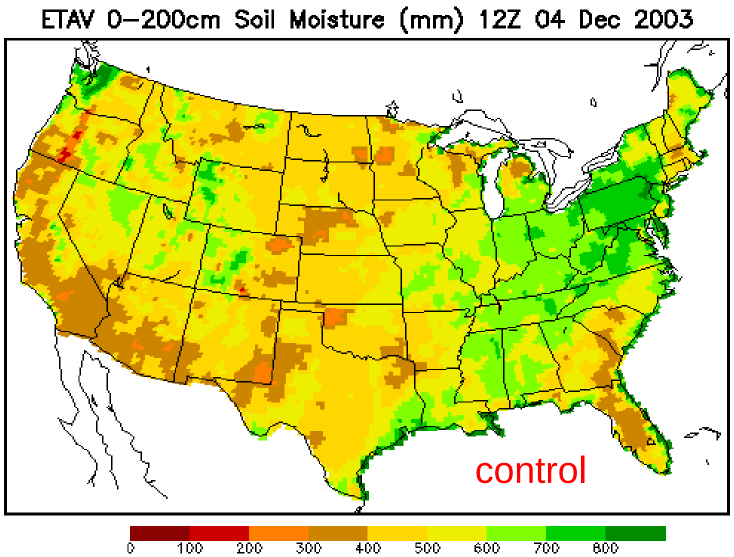
Impact in 32km Parallels: Oct 6 – Dec 4 2003

EDAS precip scores: w/adjustment; control









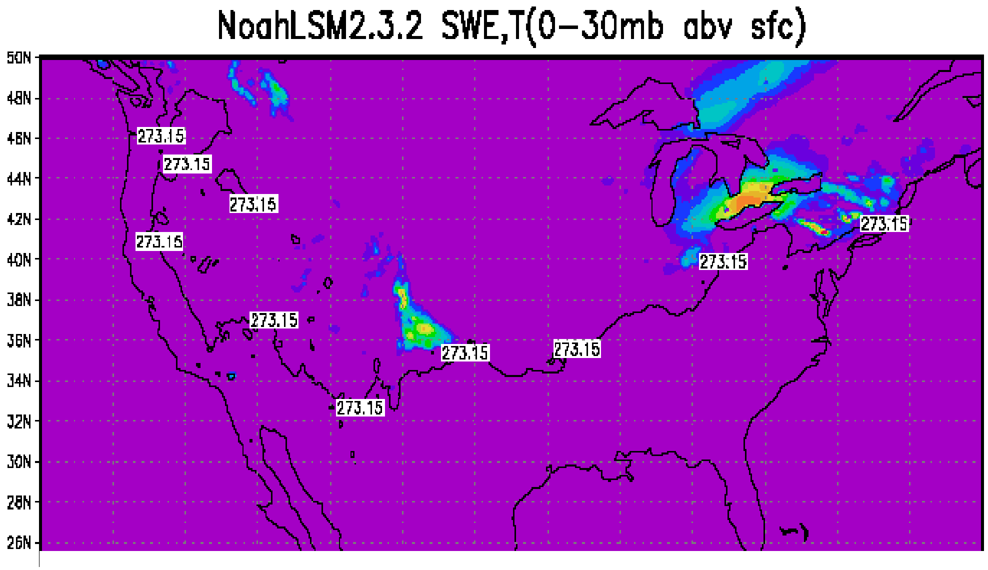
Precipitation Type used in Noah LSM

Use predicted Ferrier type instead of diagnosed type

- Based on study by Lackmann *et al*. (2002 WAF)
  - Before: precipitation type based on air temperature in the lowest model layer (T_{sfc})
    - Snow if $T_{sfc} < 0C$, rain otherwise
  - Change: precipitation type based on model microphysics (F_{froz}, fraction of frozen precipitation)
    - Snow if $F_{froz} \geq 0.5$, rain otherwise
- Leads to:

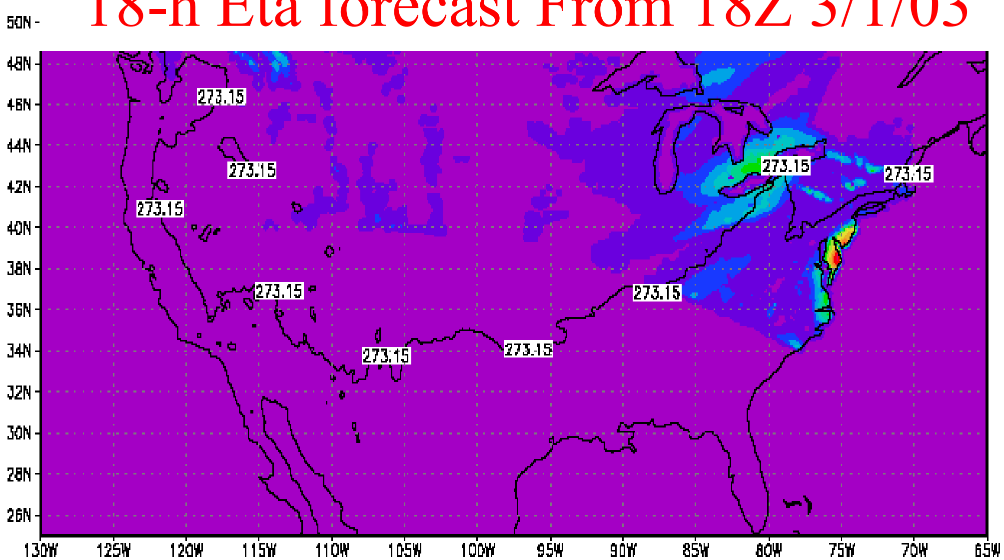
1. Warmer surface temperatures in freezing rain events (latent heating warming ground, self-limiting process)
2. Cooler surface temperatures when snow falls on surface above 0ºC (melting of snow cooling ground)

Impact of Lackmann change on Eta snow cover



Old formulation : no snow cover where T > 0C

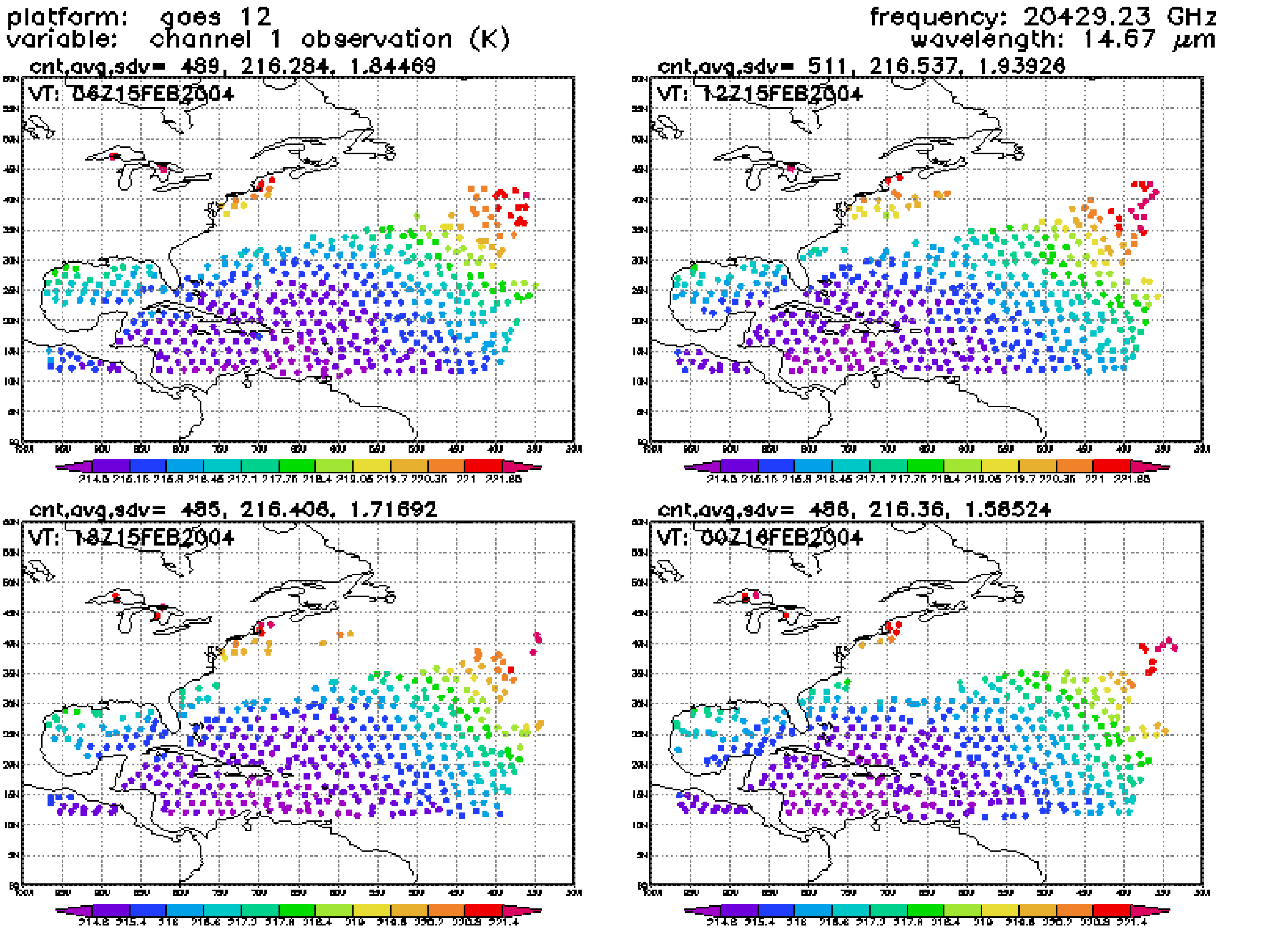
18-h Eta forecast From 18Z 3/1/03



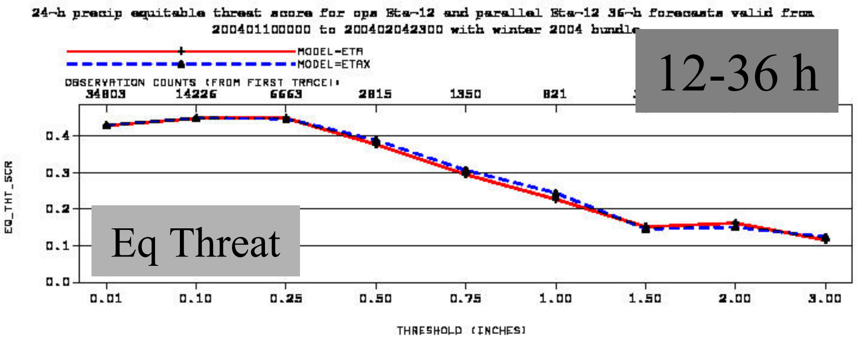
New formulation : snow cover in regions with T > 0C

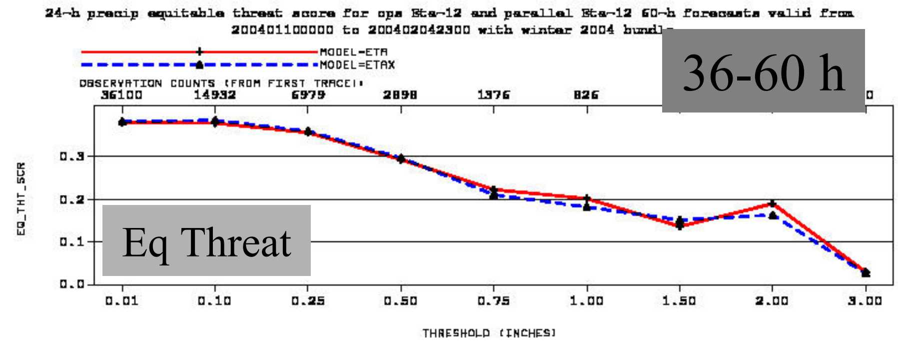
Assimilation of GOES-12 radiances

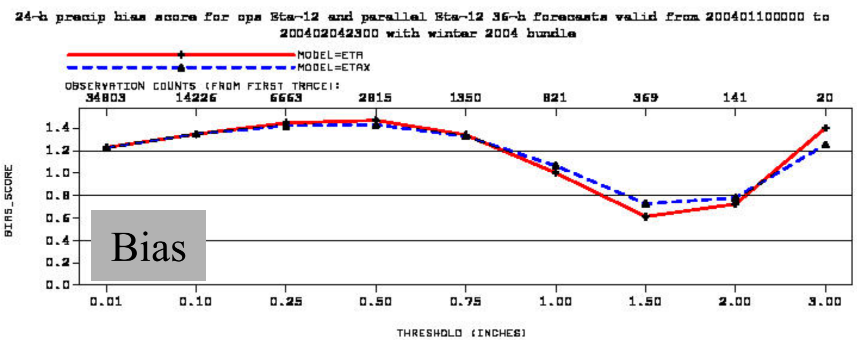
Channel 1 Brightness Temperatures 06Z 2/15/04 – 00z 2/16/04

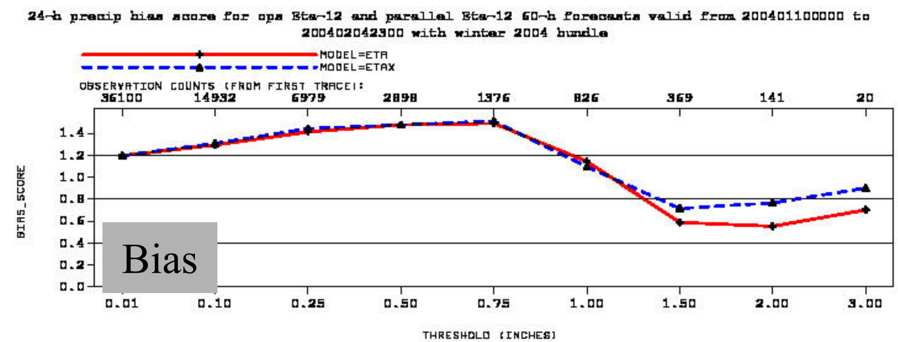


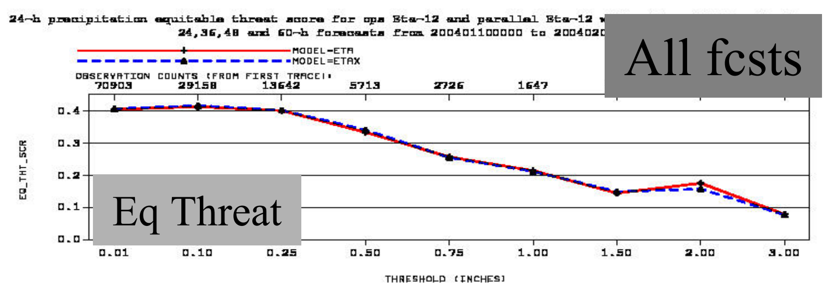
Eta-12 Parallel (blue) vs Ops Eta (red) QPF Scores : 1/10/ – 2/18/04

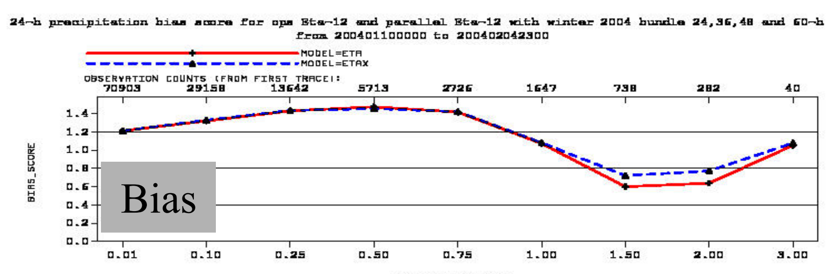






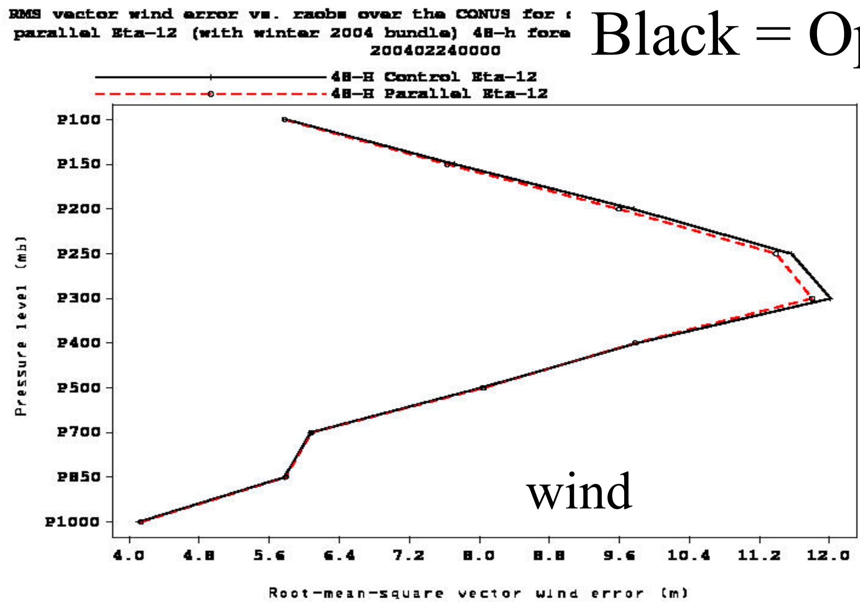


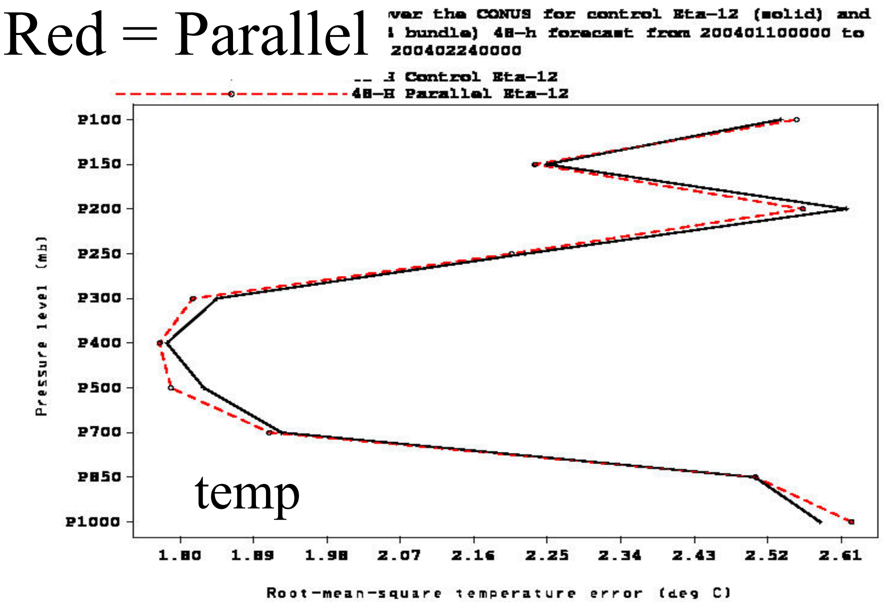


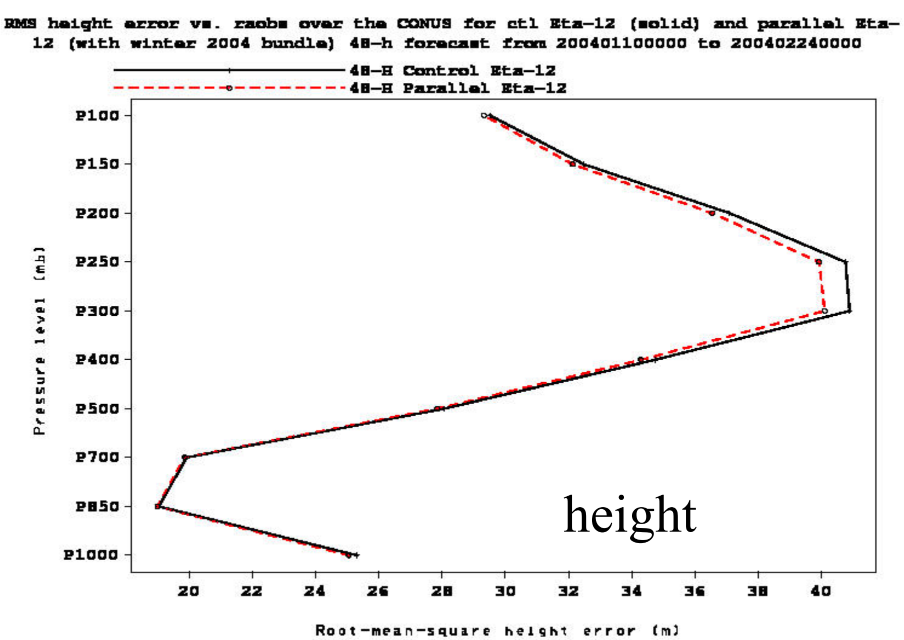


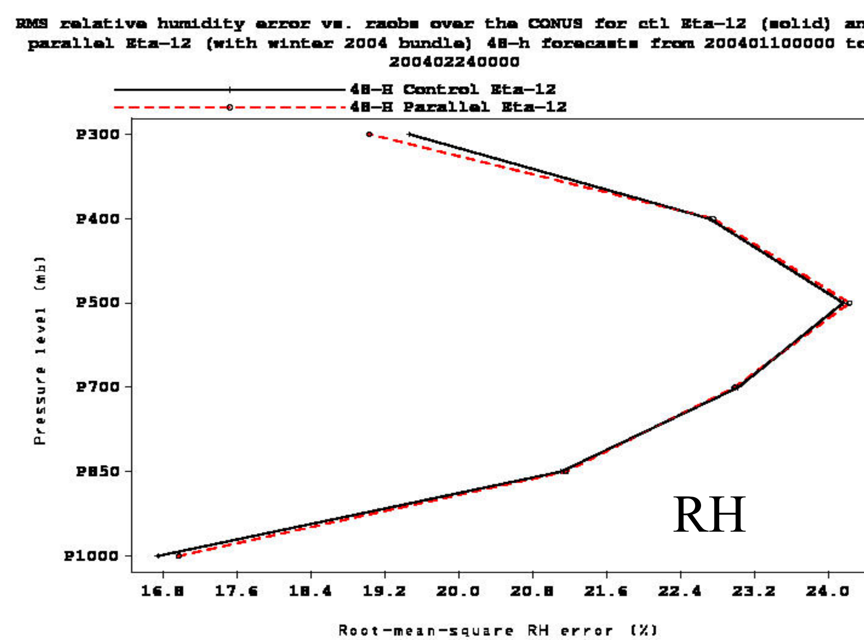
48-h forecast RMS fits to CONUS raobs : 1/10 – 2/24/04

Black = Ops, Red = Parallel







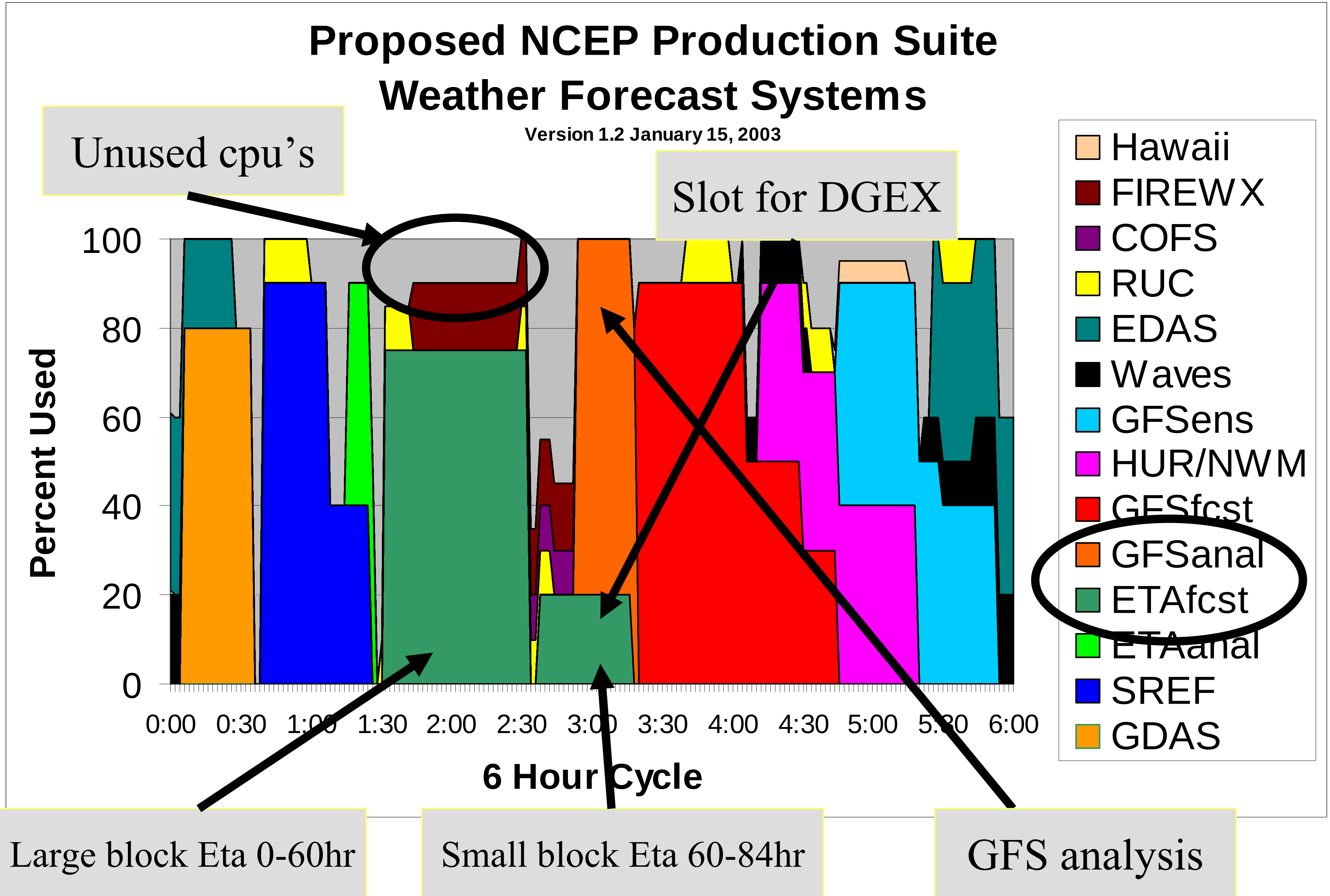


Downscaled GFS by Eta Extension (DGEX) Project Objective

- Provide NWS Forecast Offices With a First Guess National Digital Forecaster Database (NDFD) Eight Day Forecast Grid Derived from the Meso Eta Forecast Model
- Reduce the Effort Required for the WFO Forecaster to Create an Eight Day Forecast Grid for the Interactive Forecast Preparation System (IFPS)
  - GFS Grids Currently Distributed are Too Coarse in Vertical and Horizontal Resolution to Provide an Acceptable First Guess – Especially in Areas of Complex Terrain

Downscaled GFS by Eta Extension (DGEX) Design

- Run 12 km Meso Eta out to 192 hr on 1/6th (or smaller) of North American domain using GFS lateral boundary conditions (LBC)
  - Effectively downscaling GFS (providing LBC) since GFS synoptic scale will dominate Eta solution in its interior especially on reduced (1/6th) domain
  - Start DGEX at 78 hr to allow for adjustment to smaller grid by 90 hr (first output time for distribution)
  - 78-174 hr uses 3-hr GFS LBC; 174-192 hr uses 6-hr GFS LBC

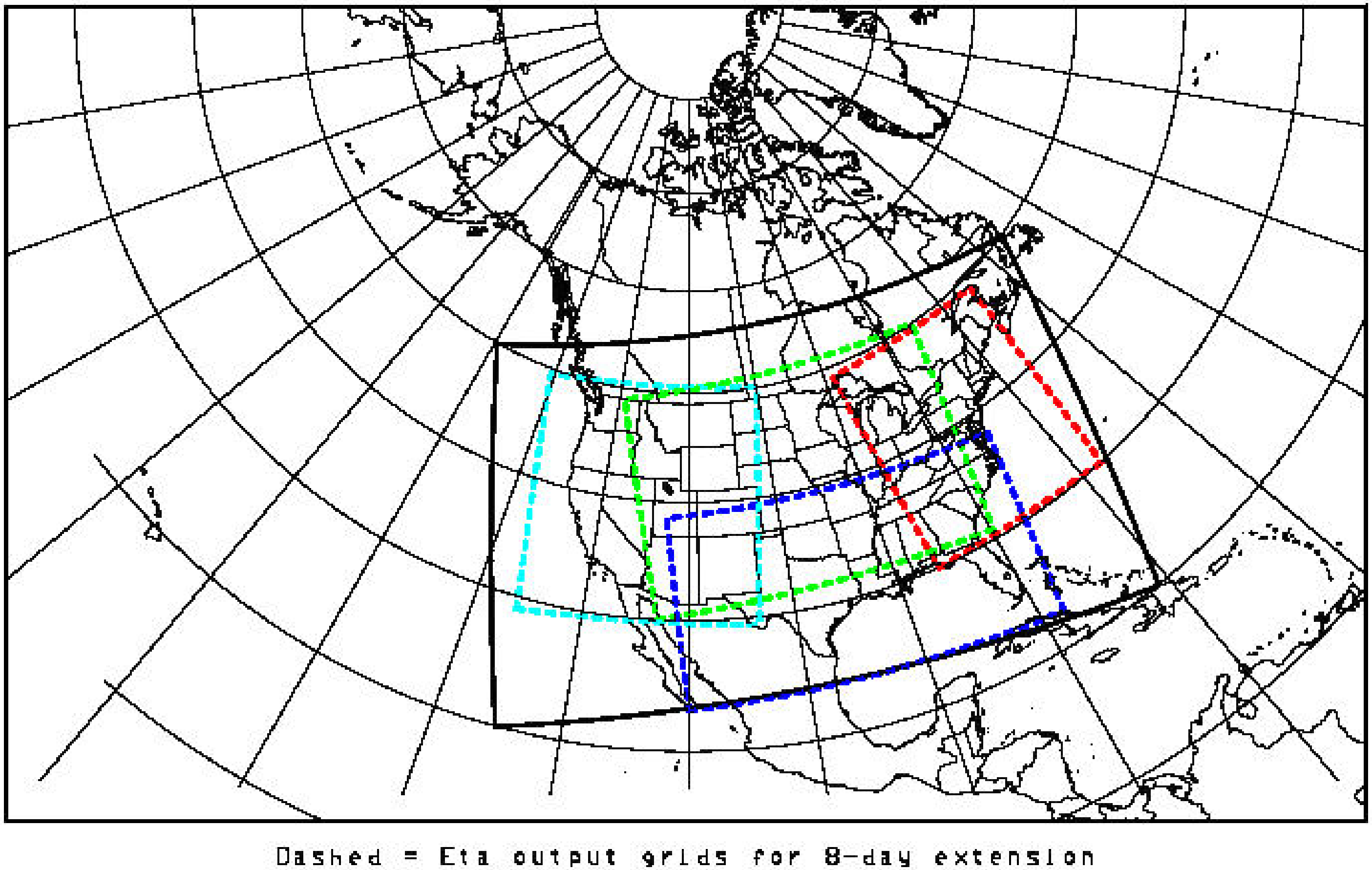

Proposed NCEP Production Suite
Weather Forecast Systems
Version 1.2 January 15, 2003
Unused cpu's
Slot for DGEX
Percent Used
100
80
60
40
20
0
0:00
0:30
1:00
1:30
2:00
2:30
3:00
3:30
4:00
4:30
5:00
5:30
6:00
6 Hour Cycle
Hawaii
FIREWX
COFS
RUC
EDAS
Waves
GFSens
HUR/NWM
GFSfcst
GFSanal
ETAfcst
ETAanal
SREF
GDAS
Large block Eta 0-60hr
Small block Eta 60-84hr
GFS analysis

DGEX Configuration

- Cycle times – run twice per day per domain
  - 06 and 18Z (00 and 12Z GFS LBC) for CONUS
  - 00 and 12Z (06 and 18Z GFS LBC) for OCONUS
- Initial Evaluation Phase (March 2004)
  - Single run per day
  - Run off EMC's 00Z parallel
- First Development Phase (April 2004)
  - Extend current 0-60 hr off-hour Eta out to 84 hr, freeing up old 60-84 hr time slot for DGEX

DGEX CONUS Domain

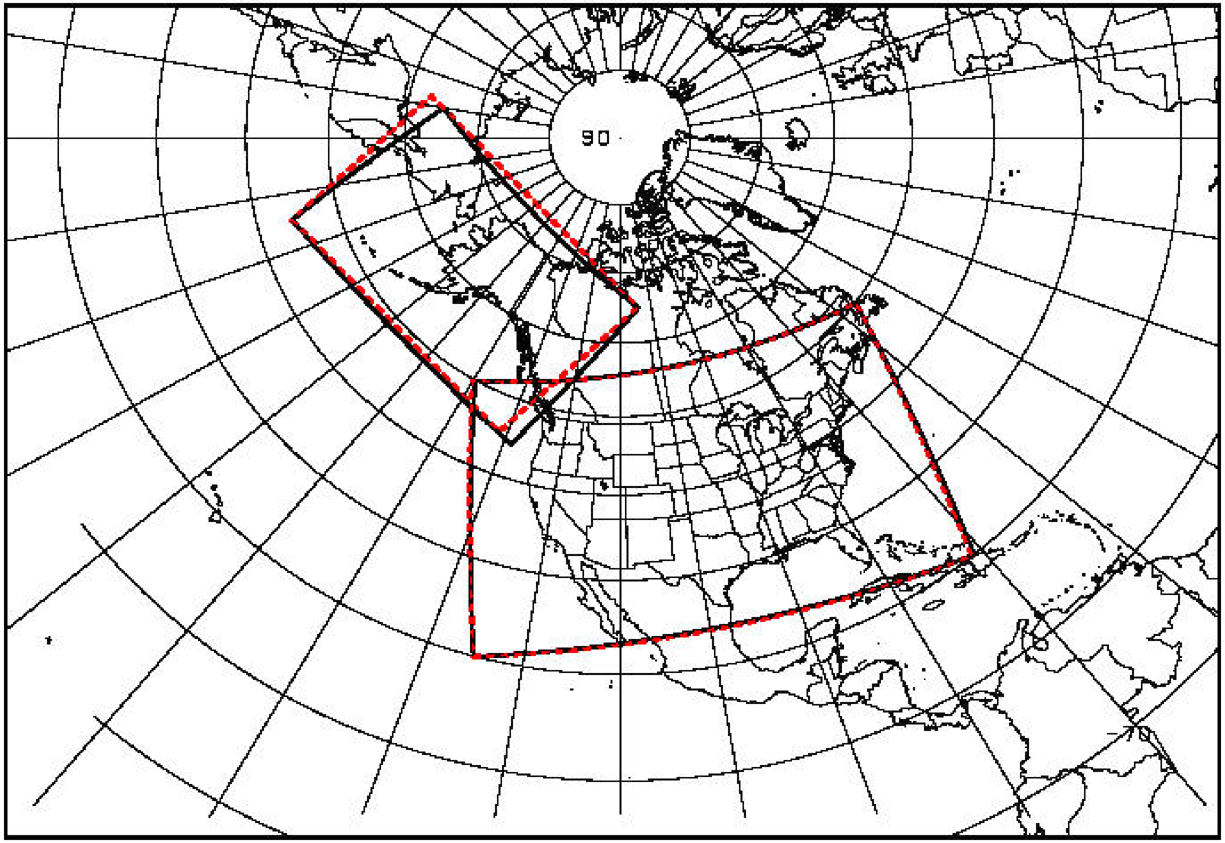
With Regional Distribution Tiles



Regional subsets were generated by EMC only during field evaluation period

Final distribution is on grid #218 with GRIB2 compression via new AWIPS SBN

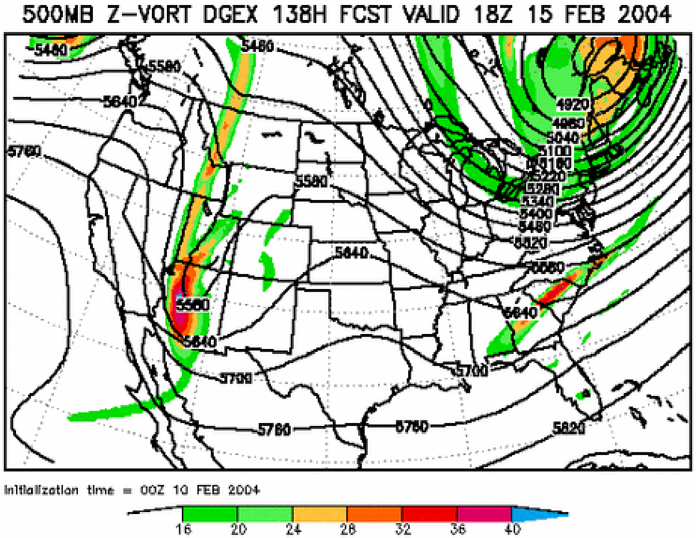
DGEX Domains

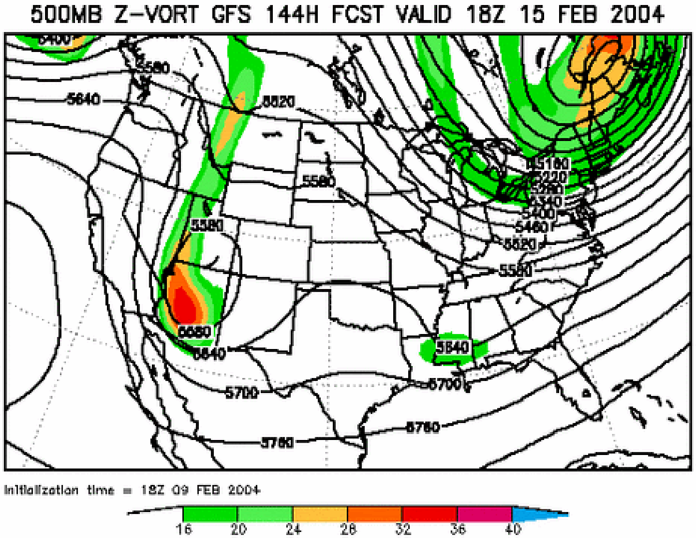


Solid black = DGEX integration grid; Dashed red = DGEX output grid

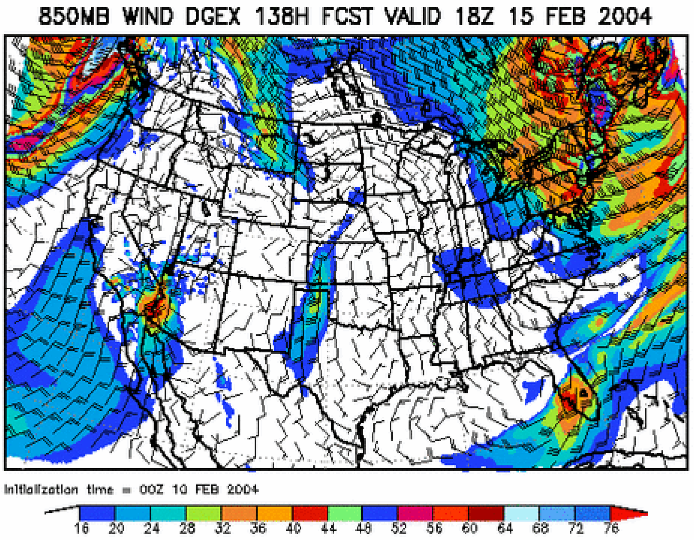
DGEX versus GFS (providing LBC)

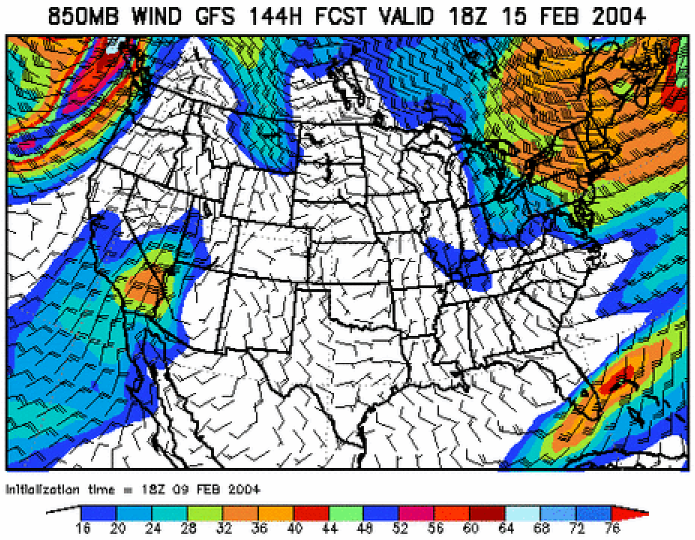
500 mb ht/Vort





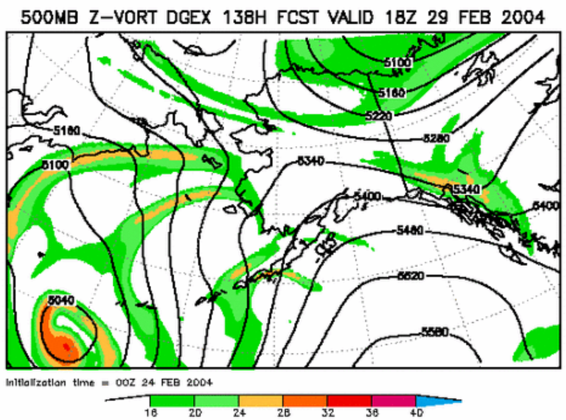
850 mb wind

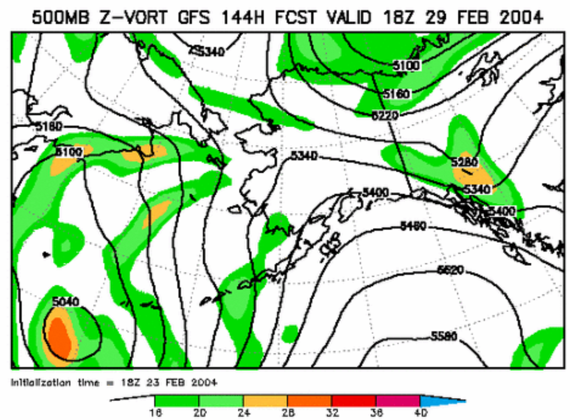




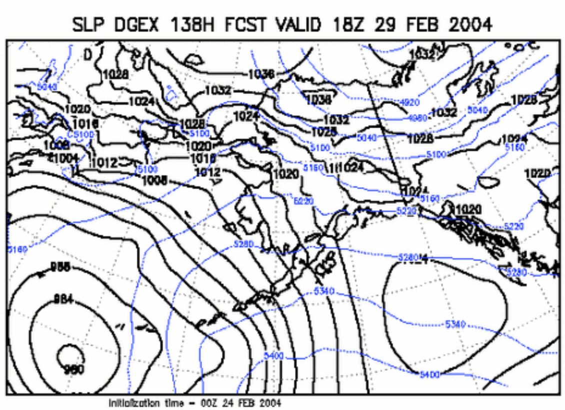
Alaska DGEX versus GFS (providing LBC)

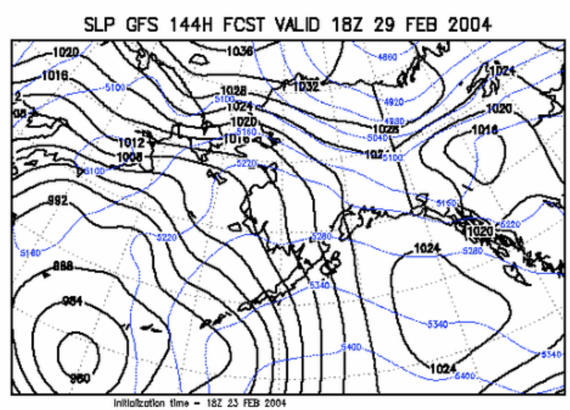
500 mb ht/Vort





SLP





DGEX SBN/AWIPS Timeline

- Late May: DVB-S efforts free up SBN bandwidth
- June 1: DGEX operational at NCEP
- June-July: OB3.2 upgrade to AWIPS configuration to allow unpacking of GRIB2 compressed files
- Products Disseminated Through the TOC to the NCF Onto the SBN TG2 Channel
  - Formatted in GRIB2 With Compression
  - Output from 90-192 hr in Six Hour Increments
  - Limited Number of Forecast Parameters Output for Intended Use Within IFPS/NDFD

DGEX Scientific Assessment

- 15 March – 20 April: Test and Evaluation period
  - 00 UTC DGEX Run Each Day in Development
    - CONUS Domain
    - Alaska Domain
  - EMC Objective Verification
    - DGEX and GFS (to Day 8) Ingested into EMC's FVS System For Quantitative Assessment: DGEX Near-Surface Performance and "Usability"

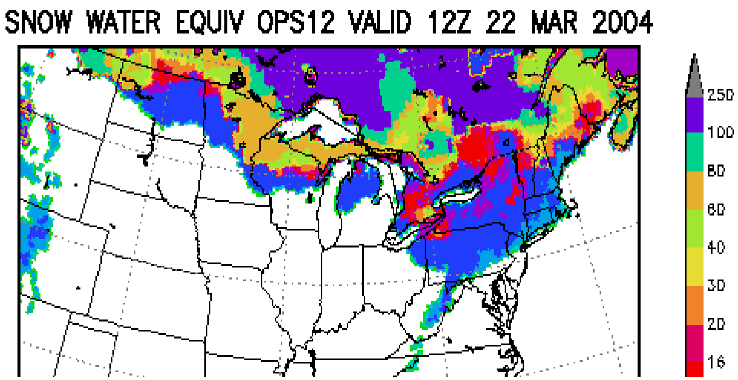
    http://wwwt.emc.ncep.noaa.gov/mmb/mmbpll/dgexhome/pllstats.dgex/
  - WFO Subjective Assessment Led By ISST
  - NCEP HPC Subjective Assessment

http://wwwt.emc.ncep.noaa.gov/mmb/mmbpll/dgexhome.ops/DGEX_combined.htm

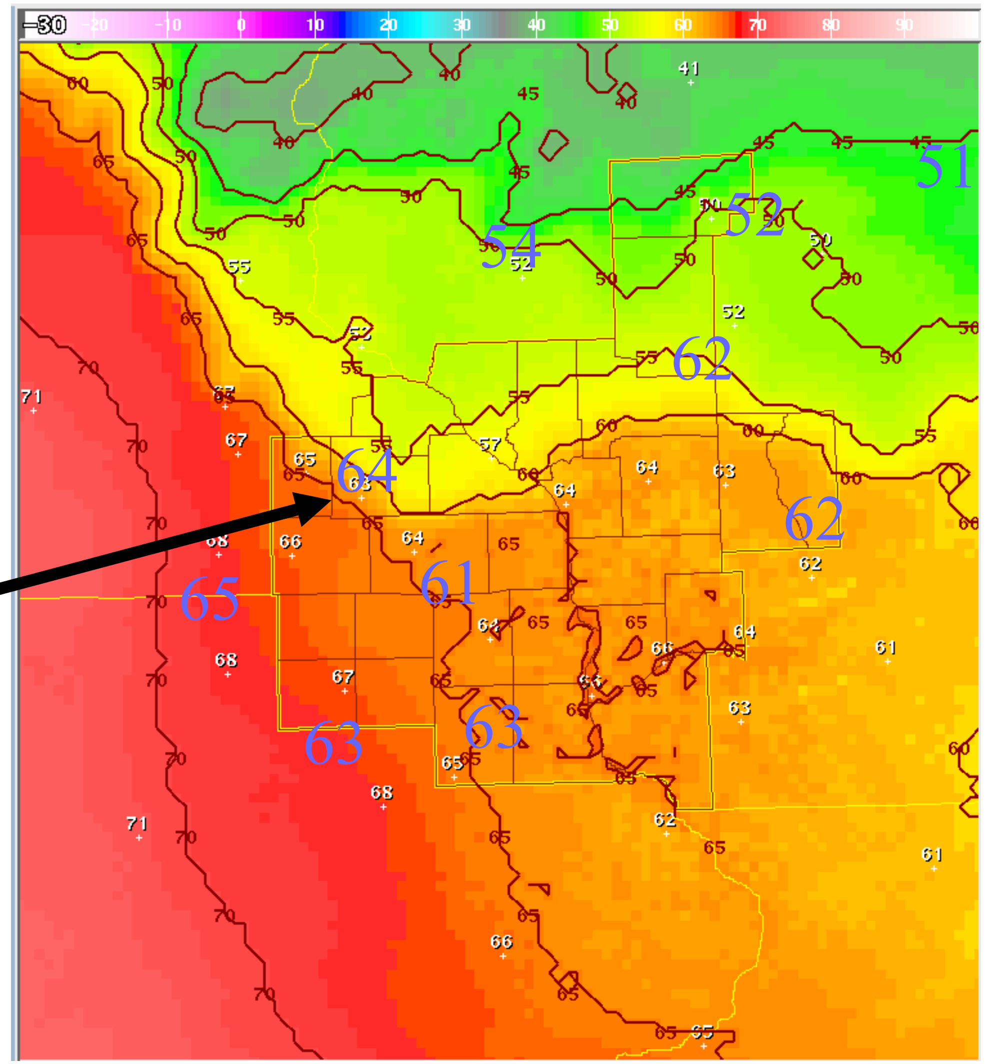
EMC Objective Verification Summary

- Upper-level Verification vs Raobs
  - DGEX Errors Comparable or Slightly Better Than 6-h Old GFS Run Providing the Lateral Boundary Conditions
- Near-Surface Verification of Temperature Winds
  - Mean DGEX 2-m Temperature Forecasts Closer to Observed Mean Than GFS for All Regions Except Nighttime Minimum in Alaska
    - DGEX Does Best in Western Region
  - Much More Diurnal 10-m Wind Speed Variations Then GFS
    - WFOs Liked DGEX Wind Directions Over GFS

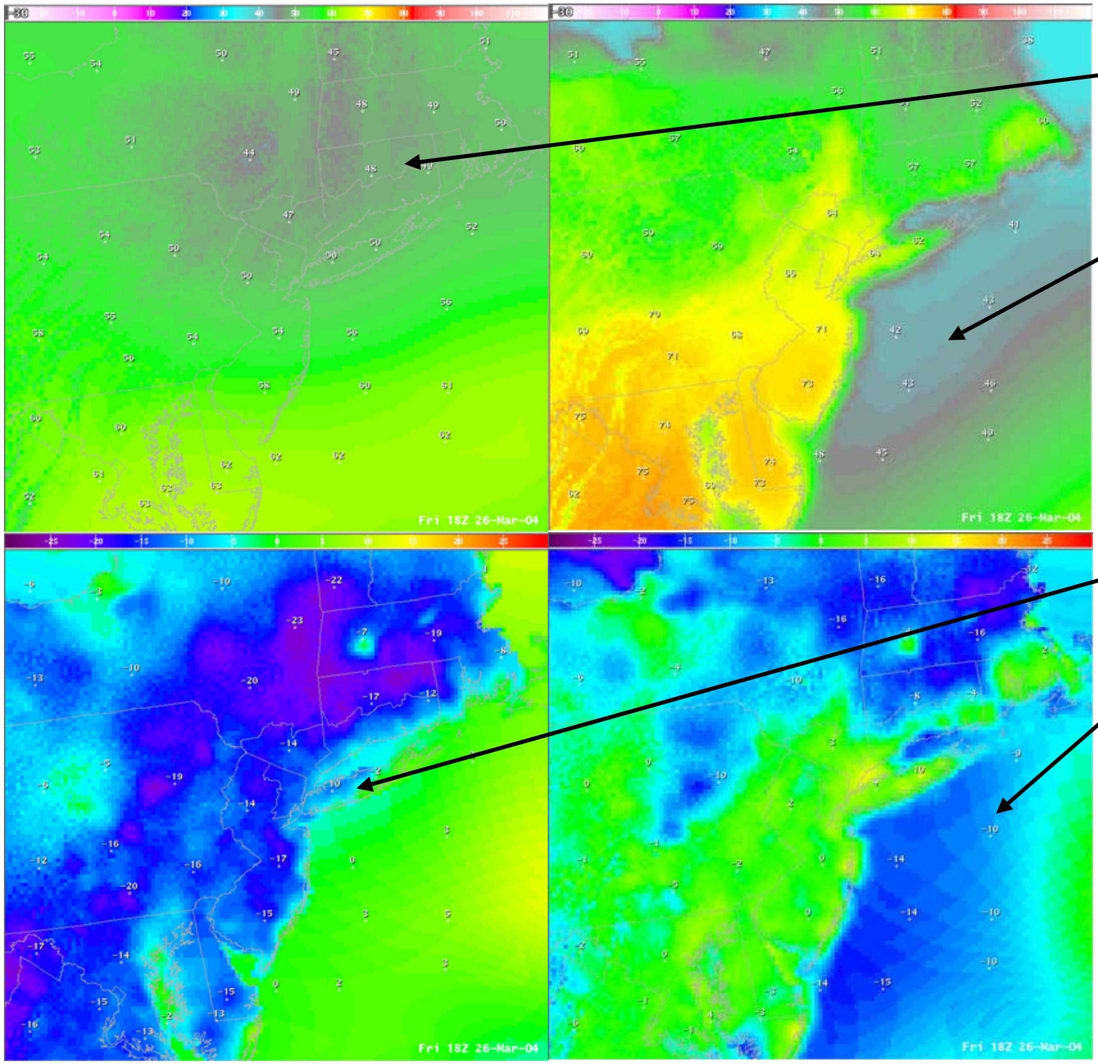
LaCrosse Example – from Dan Baumgardt



- Eta Snow Cover Reflected in the Day 4 Max-T Grid
- Verified Temps in Blue
- DGEX Very Useful to Modify Forecast Max-T



Eastern Region Example – from Dave Novak



- 90 hr GFS Forecast Verifying 18Z March 26
- 90 hr DGEX Forecast Verifying 18Z March 26
- LAPS Used as "Ground Truth"
- GFS Forecast Error
- DGEX Forecast Error
- DGEX <u>Significantly Reduces</u> the Error

ISST Subjective Assessment

- 10 WFOs Participated in Assessment
  - 9 CONUS WFOs and Fairbanks, Alaska
- Data Sent via Regional WANs
- On-line Survey to Subjectively Assess DGEX on Daily Basis
  - 11 Questions
  - Filed After Shift Responsible for Inputting Day 7 Into the Grids
  - 135 Surveys Returned With Feedback

ISST Assessment Summary

- Majority of Forecasters Found DGEX to be Useful
  - Many Positive Comments on Realism and Value of Forced Mesoscale Detail
  - Wind Grids Were Used Most Often and Deemed to be of the Best Quality
  - Favorable Assessment Even with a Few Drawbacks
    - Timeliness
    - Data Outages
    - Limited Availability

N
C
E
P

Fire Weather / IMET Support From NCEP: Selectable Runs of Nonhydrostatic Mesoscale Model

Geoff DiMego Mesoscale Modeling Branch EMC
geoff.dimego@noaa.gov   301-763-8000 ext7221

Where the Nation's climate and weather services begin

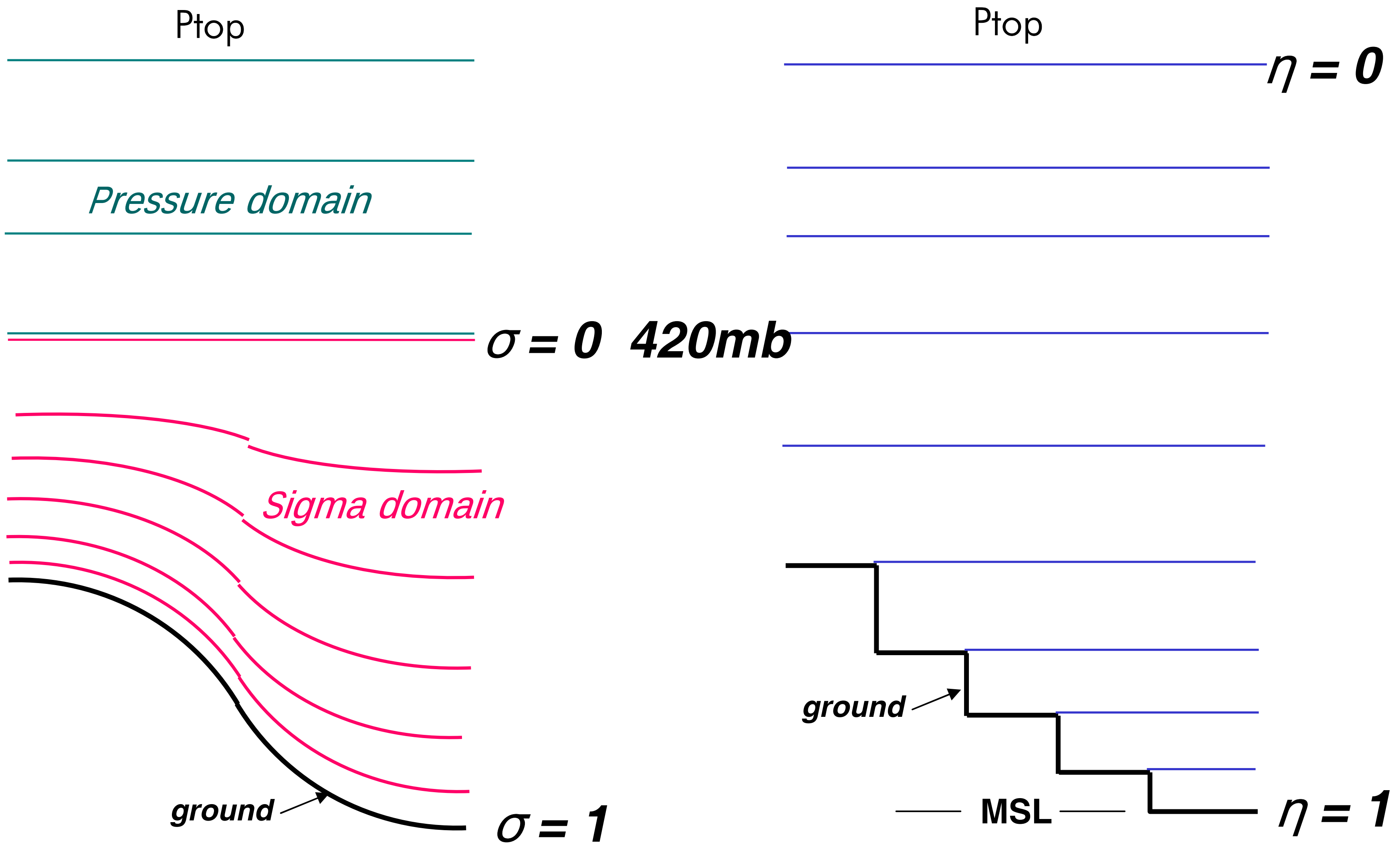
Nonhydrostatic Mesoscale Model (NMM)

- See Janjic, Gerrity,and Nickovic, 2001 for model equations, solution techniques & other test results [MWR,Vol. 29, No. 5, 1164-1178]
- Highly refined version of nonhydrostatic option released in May 2000 upgrade to NCEP's workstation Eta
- NMM retains full hydrostatic capability
  - Incorporate nonhydrostatic effects through ε where ε=(1/g) dw/dt
  - Then split prognostic equations into:
    - hydrostatic parts plus
    - corrections due to vertical acceleration
  - Set ε to zero to run in hydrostatic mode

Nonhydrostatic Mesoscale Model Feature Comparison With Meso Eta

Feature	Meso Eta Model	Nonhydrostatic Meso Model
Dynamics	Hydrostatic	Hydrostatic plus complete nonhydrostatic corrections
Horizontal grid spacing	12 km E-grid	8 km E-grid for FireWx/IMET 4 km E-grid for Homeland Security
Vertical coordinate	60 step-mountain eta levels	60 sigma-pressure hybrid levels
Terrain	Unsmoothed with Silhouette treatment lateral boundary set to sea-level	Unsmoothed Grid-cell mean everywhere

Hybrid versus Step (Eta) Coordinates



Nonhydrostatic Mesoscale Model

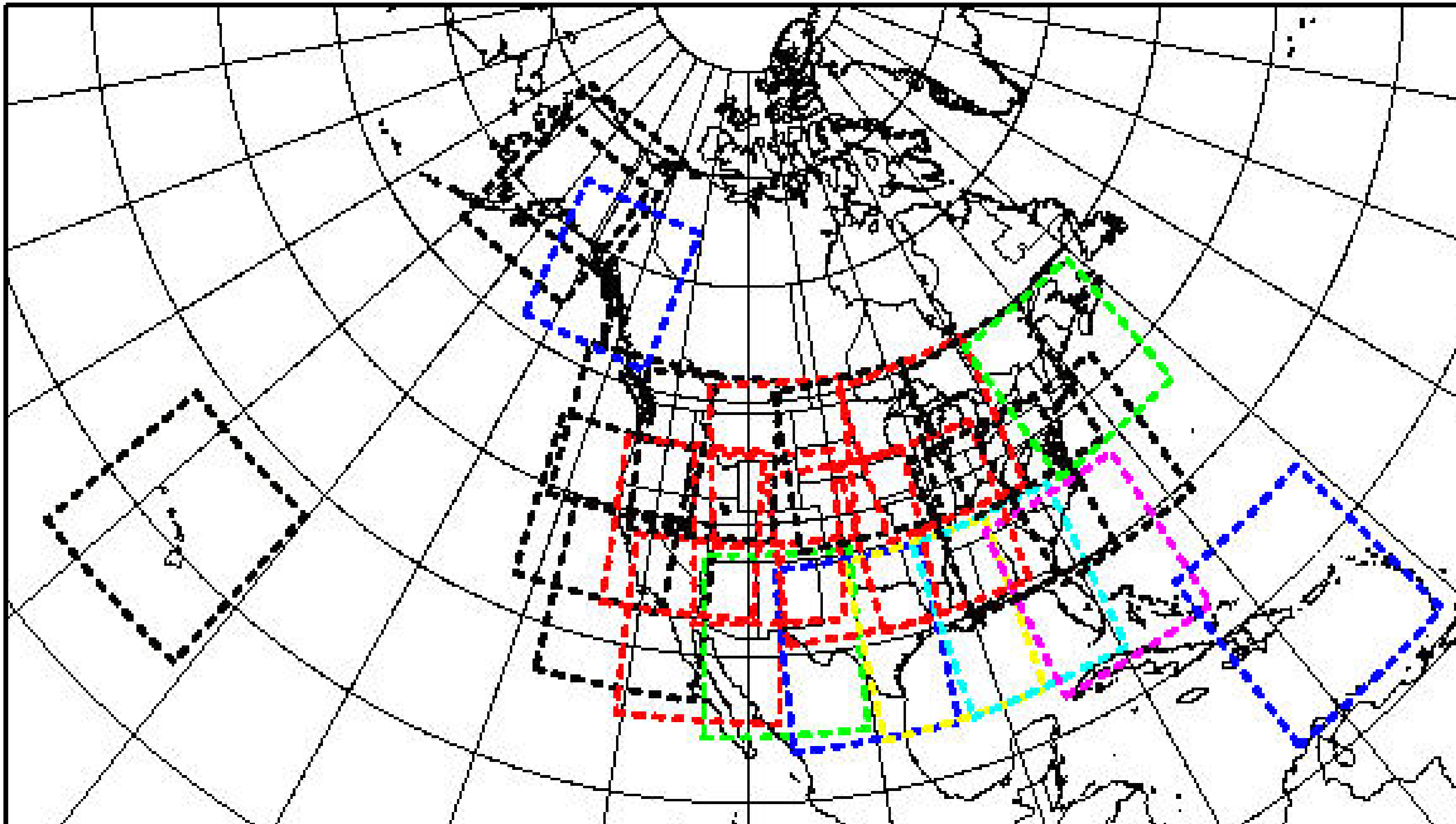
Physics Features Comparison With Meso Eta

Physics Feature	Meso Eta Model	Nonhydrostatic Meso Model
Turbulent mixing	Mellor-Yamada Level 2.5 dry	Mellor-Yamada Level 2.5 including moist processes
Surface exchange	…+ Paulson functions	…+ Holtslag and de Bruin functions
Land-sfc	NOAH LSM	NOAH LSM
Gridscale	Ferrier	Ferrier
Convective	B-M-J	B-M-J' (some retuning)
Radiation	GFDL	GFDL' (some retuning)

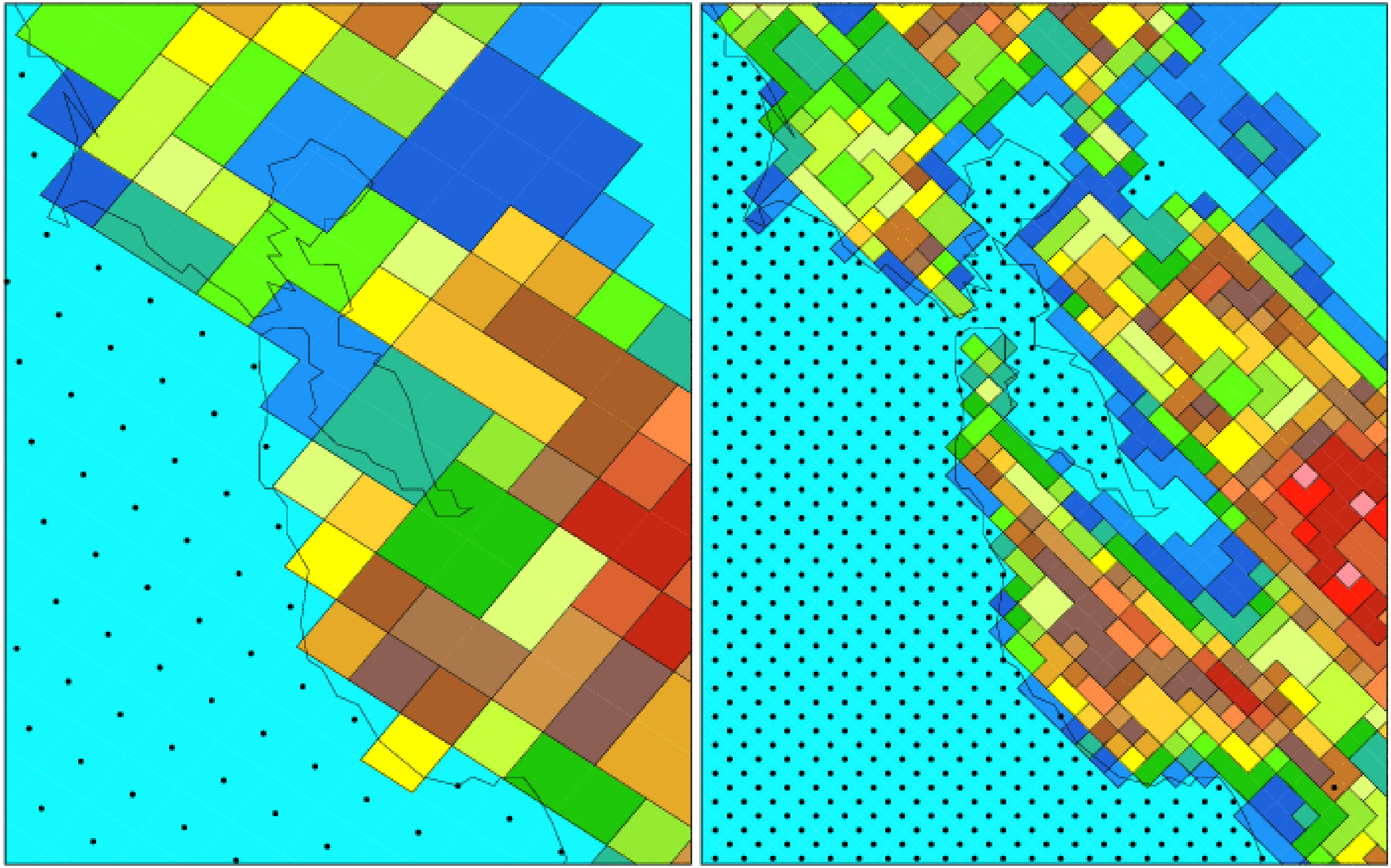
Design Considerations

- Fire Wx/IMET Support run designed to run over the top of the Eta at all four runtimes of 00z, 06z, 12z & 18z
- Better than using HiResWindow because it has no conflict with hurricane runs and finishes earlier
- Established reduced domain nests patterned after NCEP's On-Call Emergency Response capability for Homeland Security
- Nests to run at 8 km resolution like the HiResWindow
- Only downside is smaller domain than HiResWindow

26 Selectable 8 km Domains For Fire Weather / IMET Support Identical To 4 km Homeland Security Domains

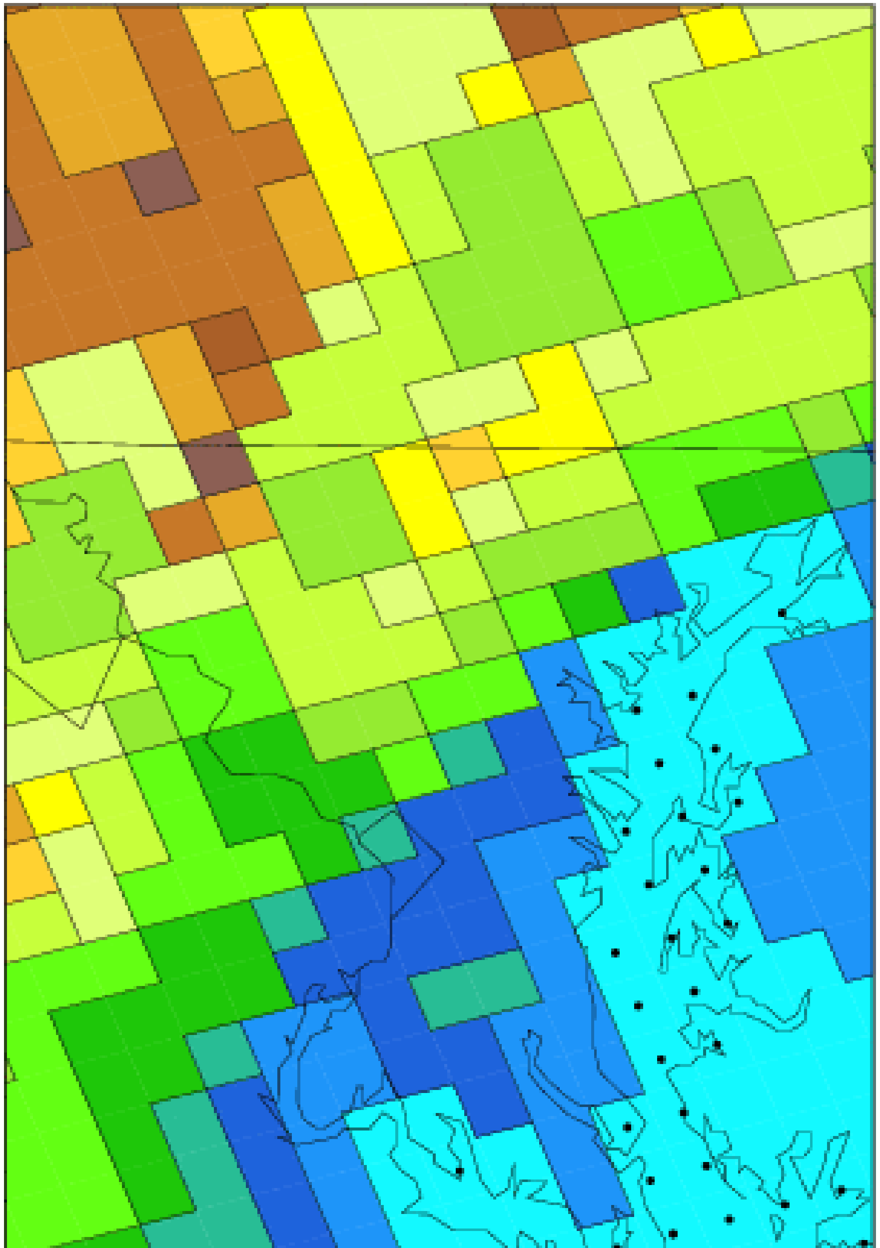


12 km Terrain 4 km Terrain

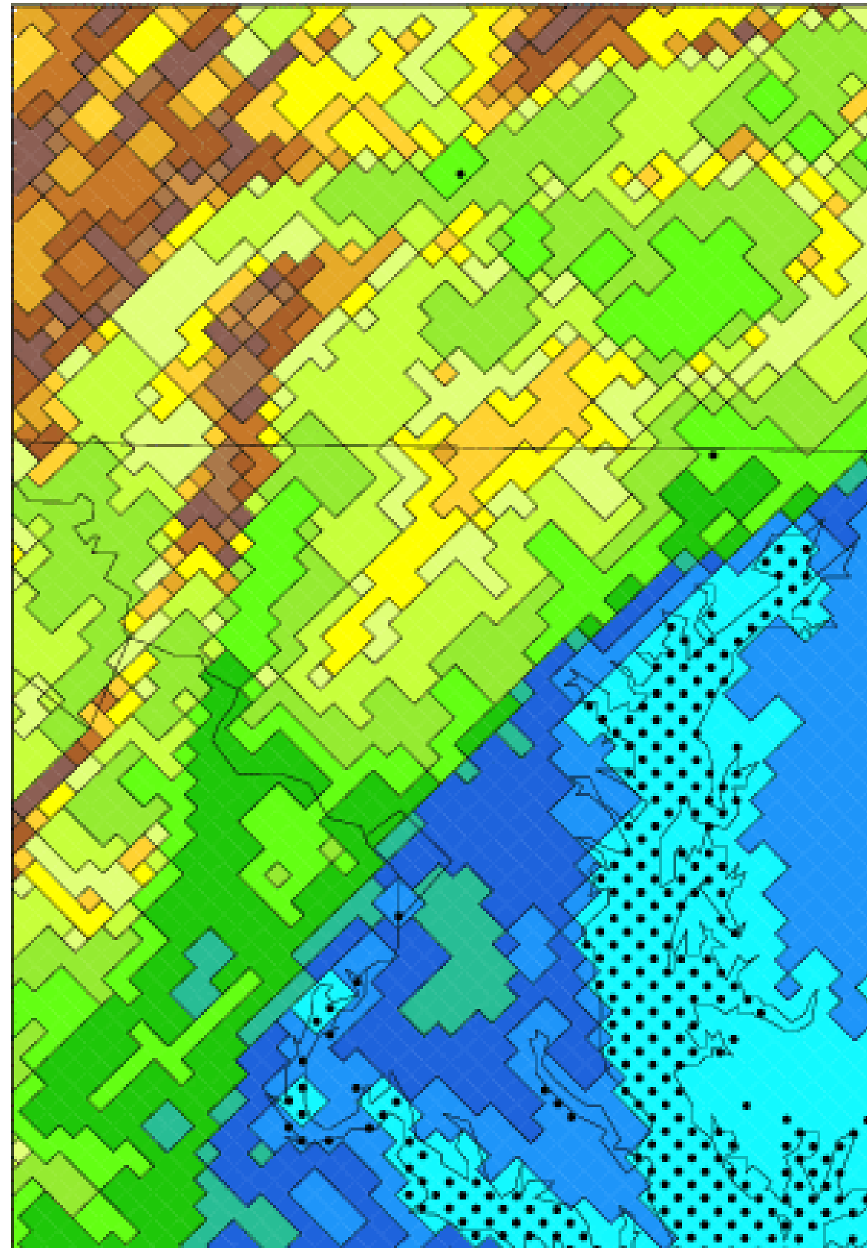


Dots represent water points Domain is San Francisco Bay

12 km Terrain

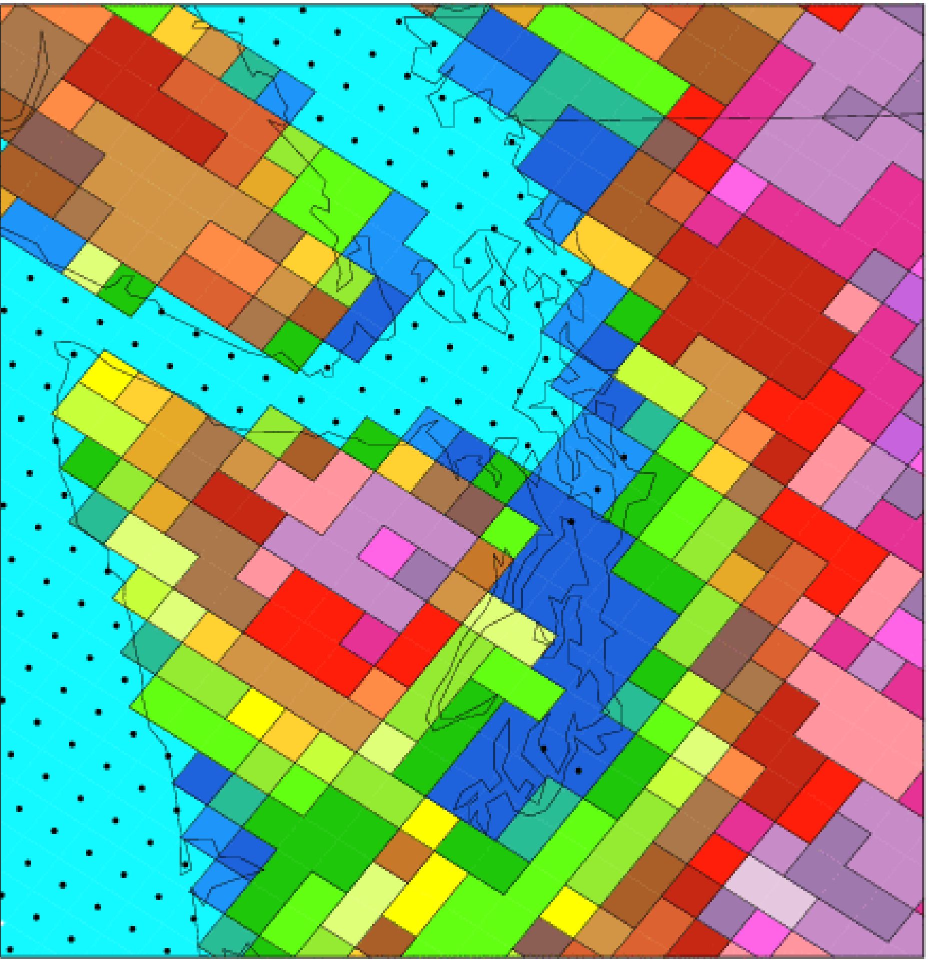


4 km Terrain

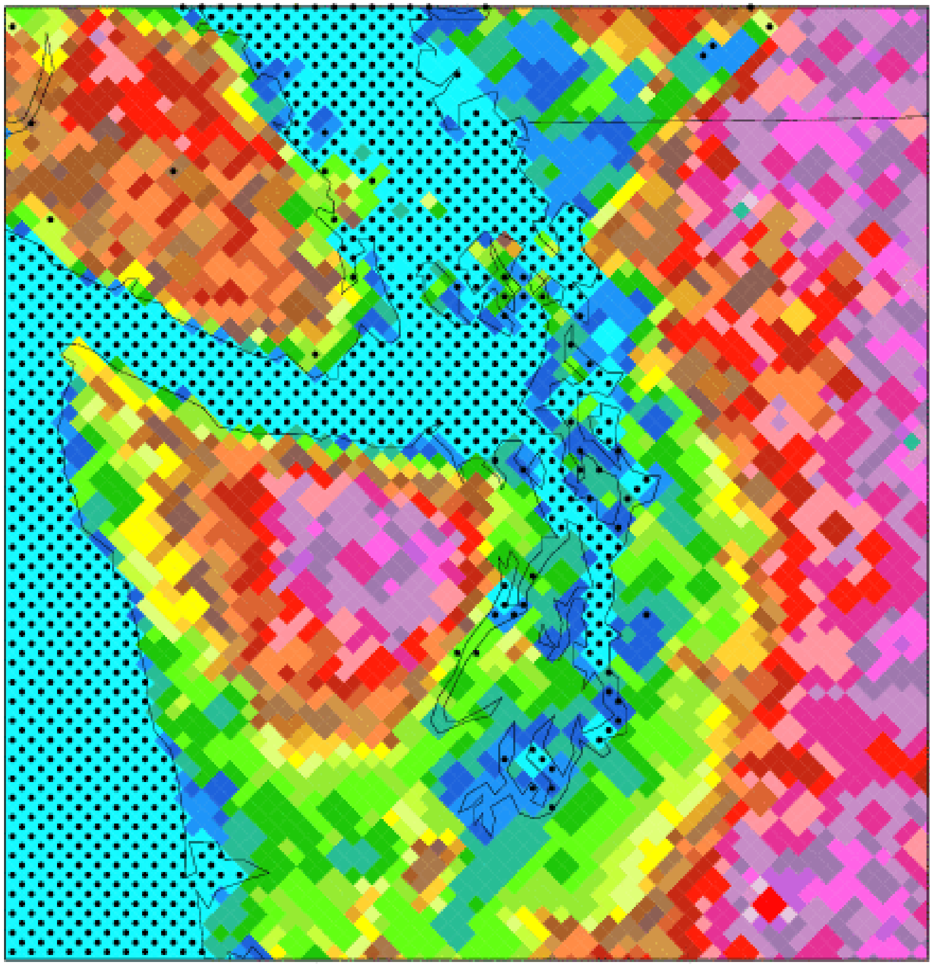


Dots represent water points Domain is Chesapeake Bay

12 km Terrain



4 km Terrain



Dots represent water points Domain is Puget Sound

Fire Weather / IMET Run Output

The FireWx grids are available out to 48 hours on the TOC ftp server (tgftp.nws.noaa.gov) under the following format: /SL.us008001/ST.opnl/MT.nmm_CY.{CC}/RD.{YYYYMMDD}/PT.grid_DF.gr1_AR.nest{xx} where

CC = 00, 06, 12, or 18

YYYYMMDD = the current date

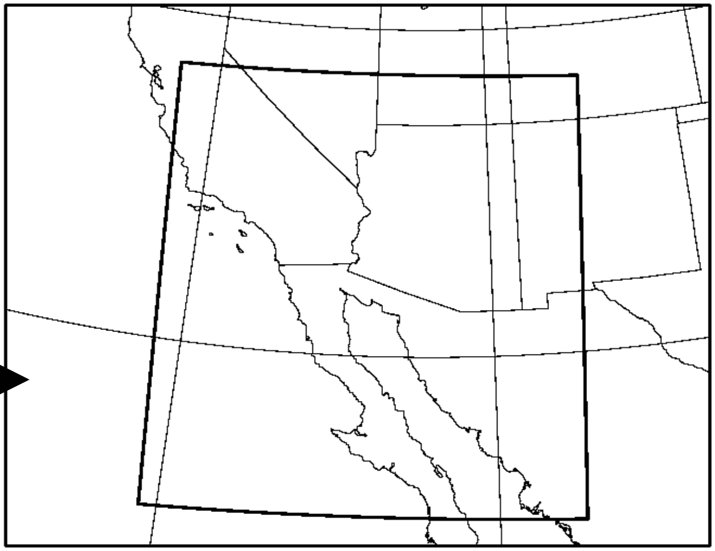
xx = 01 - 26 (geographic location)

Filenames follow the convention:

fh.{hhhh}_tl.press_gr.awpreg where

hhhh = 0000, 0003, 0006, ... , 0048

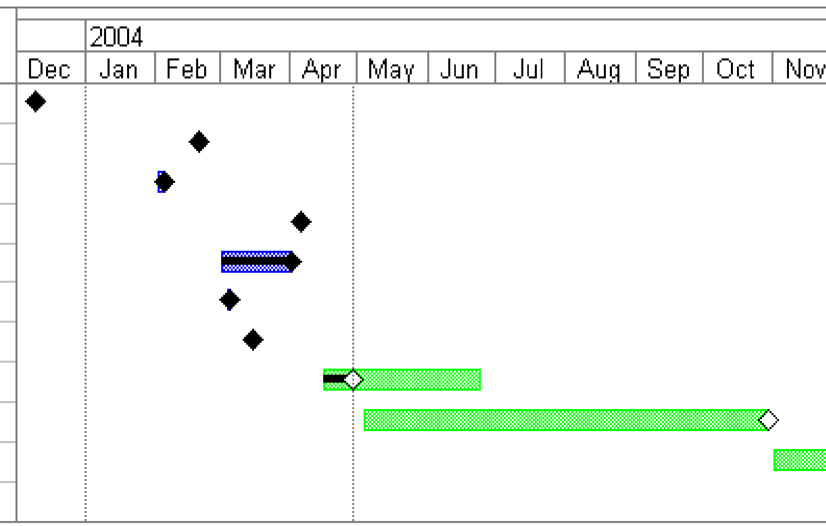
File on TOC with gif of region



8 km Fire Weather Domain fw02

Current Plans for 2004 Season: Training Given to IMETs, IMETs to Provide Feedback Following FX-Net Upgrade

ID		Task Name
1	✓	Initial Coordination
2	✓	Dry Run of Jascourt Training
3	✓	Test Fire Weather End-End Comms
4	✓	SDM Readiness (SOPs in place)
5	✓	Complete and test FX-Net Upgrades
6	✓	Complete Training
7	✓	IMETs Directed to provide ongoing NMM feedback
8		Repeat End-to-End Testing
9		Ongoing Coordination with SPC,BOI, and IMETs on Tiles
10		Comments on NMM Fire Wx Support Summarized
11		Summary of IMET Feedback Presented at EMC Review



Fire Weather / IMET Support Run 2004 Readiness Review

- Brief Description: The FWNM runs will only be available on the WR FX-NET server. The WR FX-NET domain covers the western U.S., roughly west of Colorado/Kansas border. The IMET selects and displays the FWNM fields using the laptop based FX-NET client called AMRS. The FWNM fields displayable in FX-NET are:
  - Temperature (2 m)
  - Dewpoint (2 m)
  - RH (2 m, 700 mb)
  - Winds UW/VW(10 m, 850 mb, 700 mb)
  - Sea-Level Pressure - emsp (Eta reduction)
  - Sea-Level Pressure - pmsl (NWS reduction)
  - Total Precipitation
  - Cape
  - Precipitable Water (PW)

Fire Weather / IMET Support Run 2004 Readiness Review

- The emphasis is on the near surface fields. We are not replicating the synoptic scale ETA fields already available through the AWIPS SBN fields. The FWNM is run over one of 26 sectors spread across the U.S. - of which 9 cover the WR domain of interest. The selected domain of the FWNM is relatively small, on the order of a few states. The IMETs can view the FWNM by selecting the larger regional sector and zooming in – this accommodates the possibility that the nest may change from run-to-run. The data files are stored in /data/fxa/Grid/LOCAL/netCDF/ETA08 , /awips/fxa/data/eta08.cdl , and /awips/fxa/data//localization/SLC/SLC-eta08.sup . (NOTE: these names have legacy roots and reflect Eta but will be changed next year to reflect FWNM to avoid confusion.)

Fire Weather / IMET Support Run 2004 Readiness Review

- The fire weather program leaders, Rusty and Larry, call the SDM with a request for a specific FWNM nest. The SDM who enters latitude- longitude information for the selected run at 00z, 06z, 12z and/or 18z. Test runs can be made at anytime. The only other users of this FWNM system are SPC, HPC and OPC, but their use is not continuous during the fire weather season. Central Region, which supports IMETs over the rest of CONUS, is expected to connect in FY05. Alaska Region and Pacific Region will hopefully connect in the future because FWNM nests are available centered over Fairbanks, Anchorage, Juneau, Honolulu as well as Puerto Rico.

Fire Weather / IMET Support Run 2004 Readiness Review

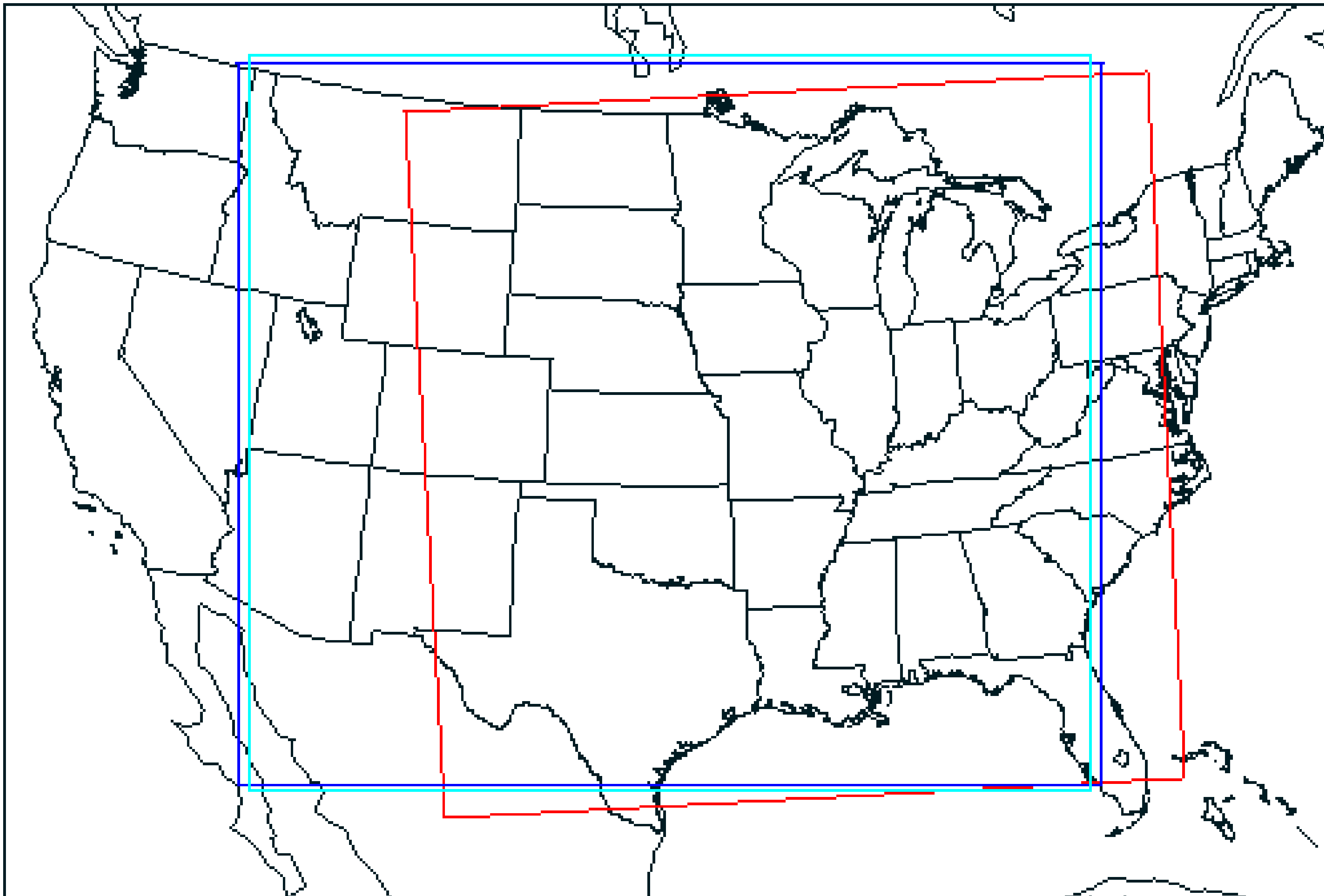
Item	Date	Activity/deliverable	Personnel
1)	12/09	Initial coordination	Cook/DiMego/Billingsley
2)	01/07	Telecon	Edman/Billingsley/Cook/DiMego
3)	02/20	Dry run of NMM Training	Jascourt
4)	01/12	Finalize output fields	Billingsley/DiMego
5)	02/04	Test end-to-end comm's	Cook/DiMego/SDM/TOC
6)	04/06	NCO/TOC coordination	Dave Caldwell
7)	02/18	Coordinate changes to FX-NET	Edman
8)	04/01	Re-localization + FX-NET upgrades	Cook/FSL/Billingsley
9)	03/14	Fire Wx / IMET Workshop:	Billingsley et al
		Jascourt presents training on NMM	
		IMETs directed to enter daily feedback in daily log	
10)	04/15	Repeat end-to-end test	Cook/SDM/WR

Special WRF-NMM Runs for SPC/NSSL Spring Program

- Beginning in April, EMC ran:
  - 4.5 km version of its WRF-NMM
  - Without any calls to parameterized convection
  - Initialized off 12 km Eta (at 40 km resolution)
  - Daily runs to 30 hours from 00z
  - Central/Eastern US domain
- SPC requested that this run be continued as long as possible

Domains of Integration for Spring Program

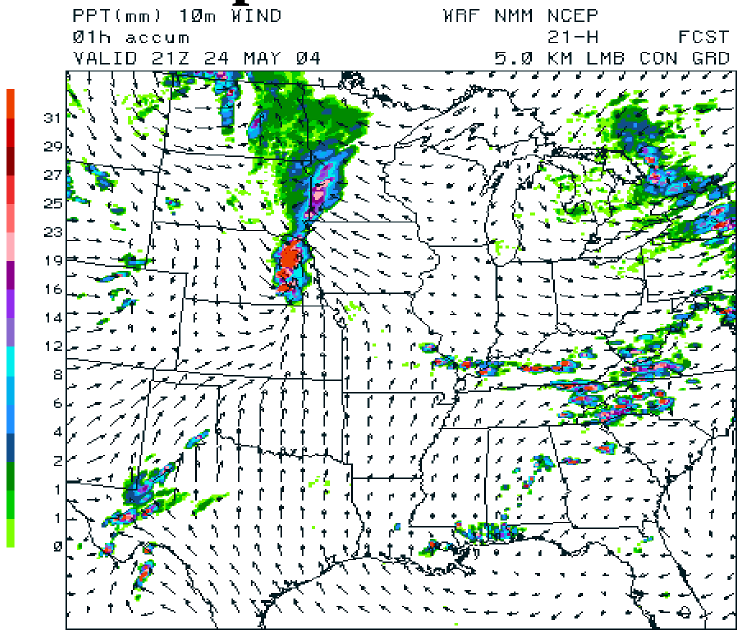
NCEP NMM (red), NCAR (blue), CAPS (cyan)



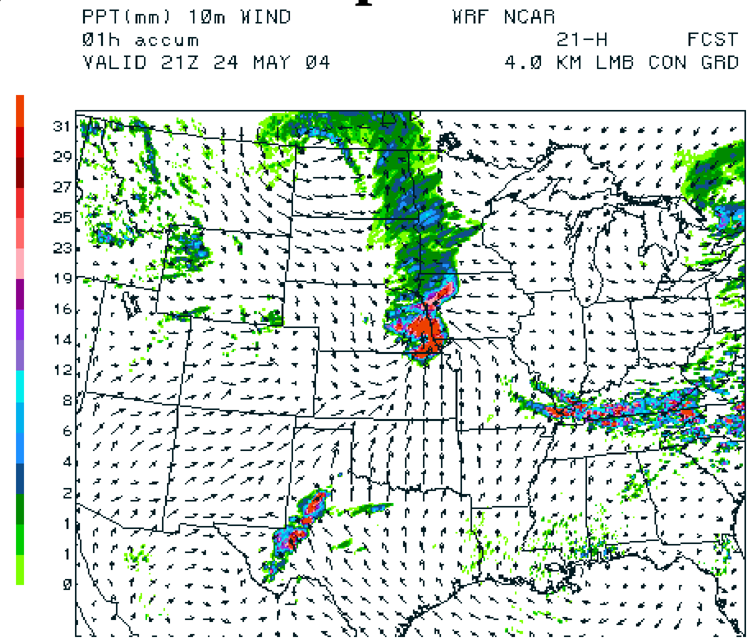
Spring Program 21 hr Forecast Example

http://www.nssl.noaa.gov/etakf/compare/wrf/

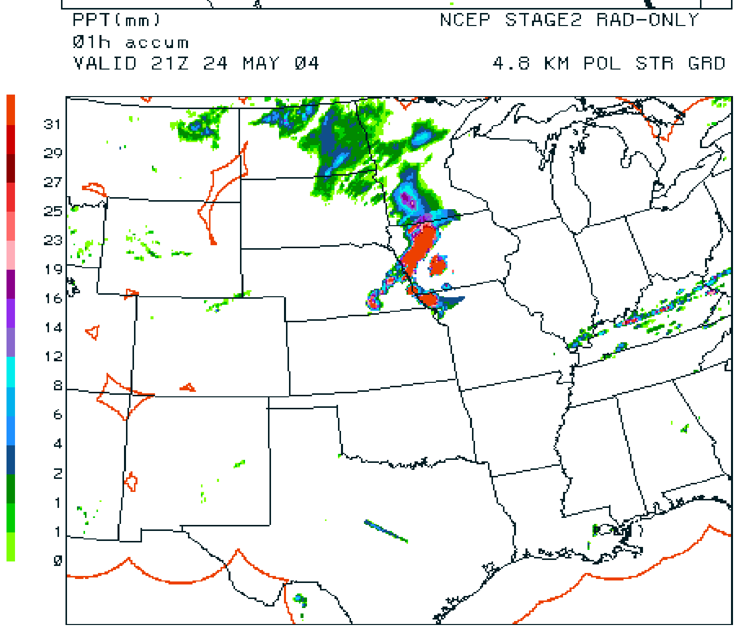
NMM



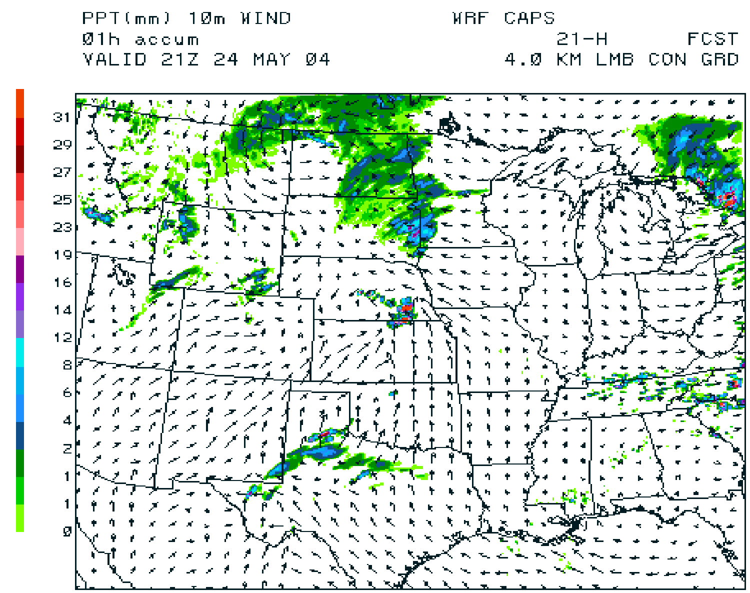
ARW



OBS



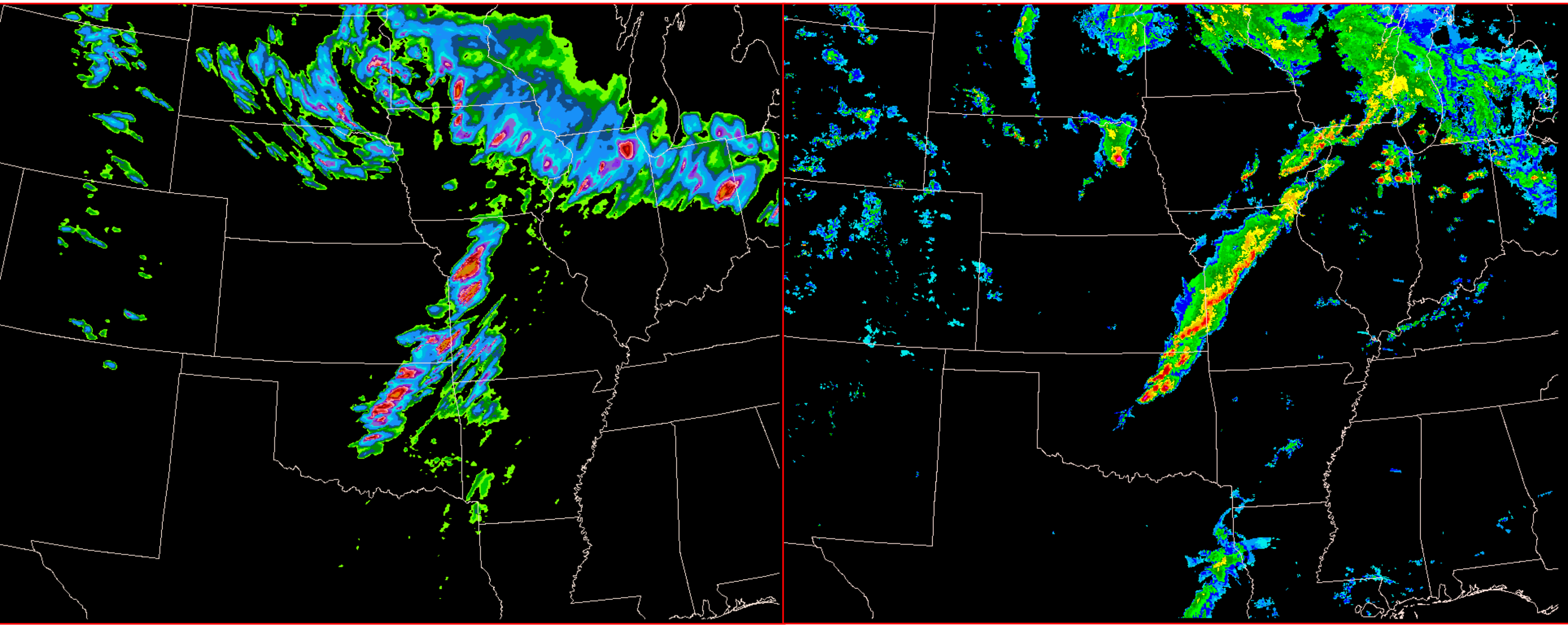
CAPS



Example of Explicit 4.5 km WRF-NMM

courtesy of Jack Kain

WRF 24 hour 4.5 km forecast of 1 hour accumulated precipitation valid at 00Z April 21, 2004 (better than 12 hour forecasts by operational models)



4.5 km WRF-NMM

Verifying 2 km radar reflectivity

Web Site Displaying 4.5 km WRF-NMM

http://www.emc.ncep.noaa.gov/mmb/mmbpll/cent4km/

1 h Precipitation totals (in.)

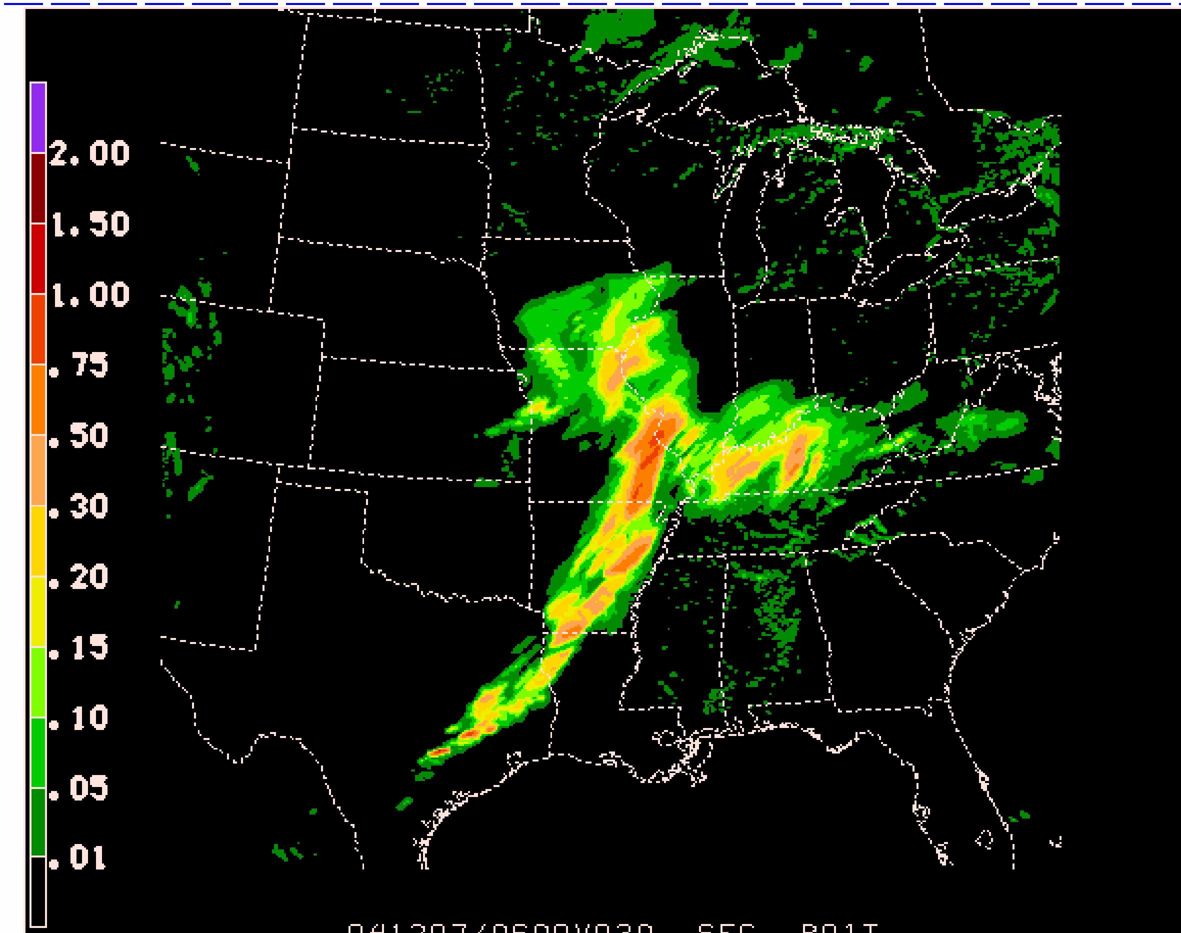
01h	02h	03h	04h
01h	06h	07h	08h
09h	10h	11h	12h
13h	14h	15h	16h
17h	18h	19h	20h
21h	22h	23h	24h
25h	26h	27h	28h
29h	30h	0-30h	NMM WRF Loop

3 h Precipitation totals (in.)

03h	06h	09h	12h
15h	18h	21h	24h
27h	30h	0-30h	NMM WRF Loop

☐ Click to animate

f01 f02 f03 f04 f05 f06 f07 f08 f09 f10 f11 f12 f13 f14 f15 f16 f17 f18 f19 f20 f21 f22 f23 f24 f25 f26 f27 f28 f29 f30



Manikin's Convective Forecasting Page

http://wwwt.emc.ncep.noaa.gov/mmb/svrfcst/index.html

SLP / 2M Dew Point

00h	03h	06h	09h	12h
15h	18h	21h	24h	27h
30h	33h	36h	39h	42h
45h	48h	51h	54h	57h
60h	63h	66h	Loop	

2M Temperature

00h	03h	06h	09h	12h
15h	18h	21h	24h	27h
30h	33h	36h	39h	42h
45h	48h	51h	54h	57h
60h	63h	66h	Loop	

Sfc-Based CAPE

00h	03h	06h	09h	12h
15h	18h	21h	24h	27h
30h	33h	36h	39h	42h
45h	48h	51h	54h	57h
60h	63h	66h	Loop	

Most Unstable CAPE

00h	03h	06h	09h	12h
15h	18h	21h	24h	27h
30h	33h	36h	39h	42h
45h	48h	51h	54h	57h
60h	63h	66h	Loop	

Mixed Layer CAPE

00h	03h	06h	09h	12h
15h	18h	21h	24h	27h
30h	33h	36h	39h	42h
45h	48h	51h	54h	57h
60h	63h	66h	Loop	

NCEP ETA CONVECTIVE FORECASTING PAGE

The current forecast cycle is **00Z 06 Dec** with graphics finished at 23:54:36 EST Fri Dec 5 2003

This page displays 00/12Z Eta model forecasts of convective parameters from the operational 12-km Eta model Some of the newer fields such as 0-1km storm-relative helicity and mixed-layer CAPE are not widely available to the field, so this site offers a chance to examine more model output. Check out a complete documentation of the output from the Eta Post Processor.

NOTE: All displayed winds are in knots. Precipitation values are in inches.

GRIB files from the operational Eta-12 forecast can be found on the NCEP ftp server or at the NWS Gateway server. Descriptions of some of these output files can be found at the EMC Eta Grid Domains page.

CHECK OUT THESE OTHER EMC WEB PAGES WITH CONVECTIVE FORECASTING INFO

- **Eta Meteograms**
- **RUC Meteograms**
- **Eta Forecast Soundings**

Get the forecasts for the previous 7 days here (link opens a new window):

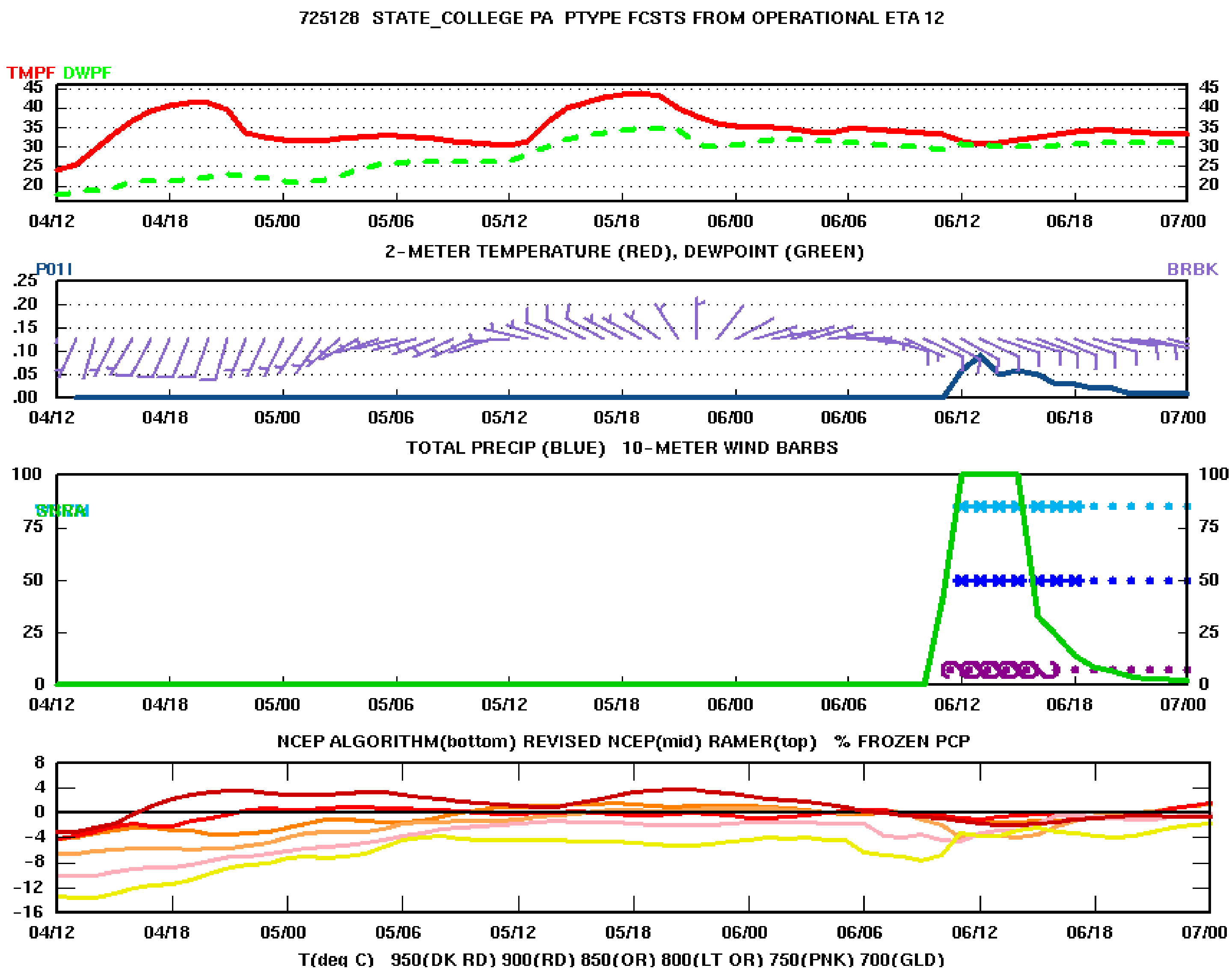
SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
12z	12z	12z	12z	12z	12z	12z
00z	00z	00z	00z	00z	00z	00z

EMC DISCLAIMER : This web page is not "operational" and therefore not subject to 24-h monitoring by NCEP's Central Operations staff.

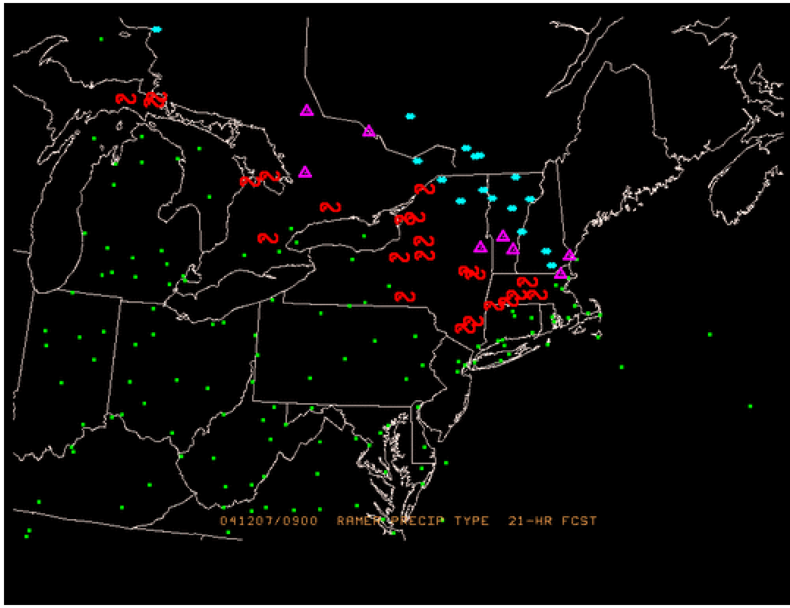
NWS Disclaimer

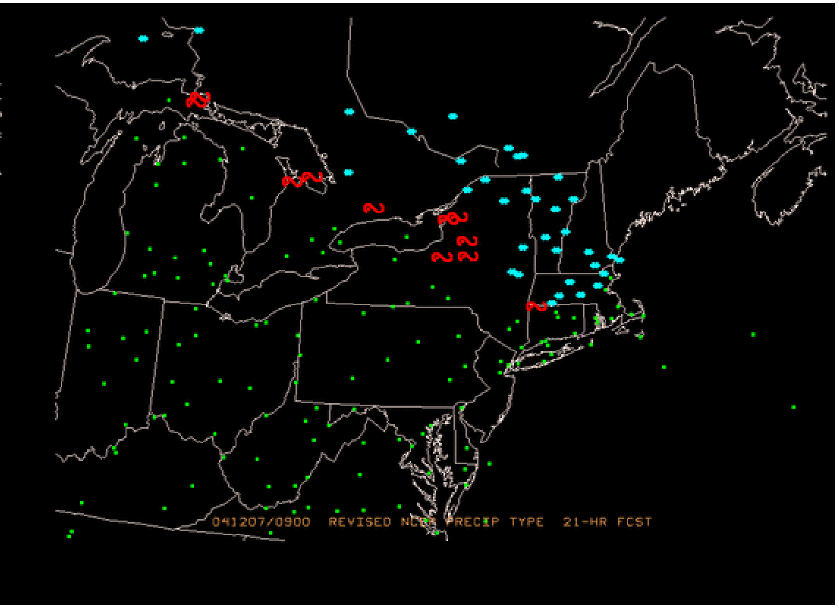
Manikin's Precip Type Meteogram Page

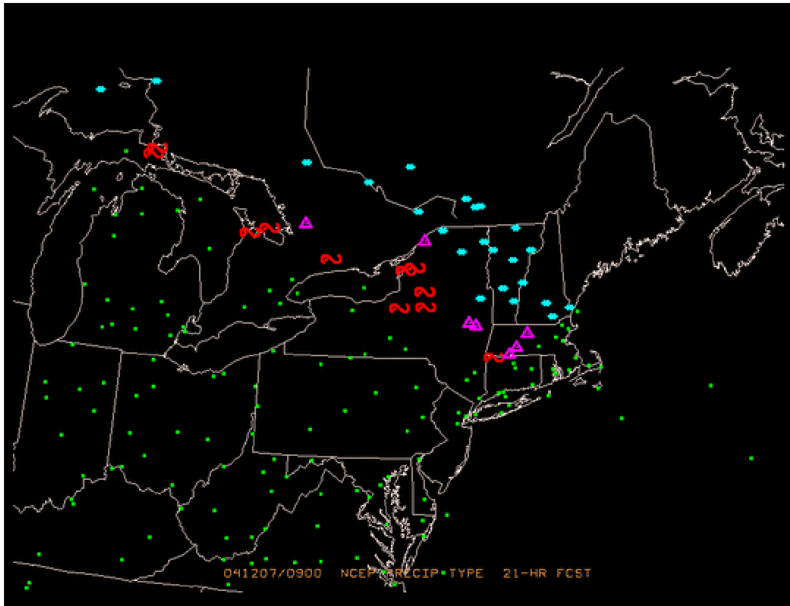
http://wwwt.emc.ncep.noaa.gov/mmb/precip_type/

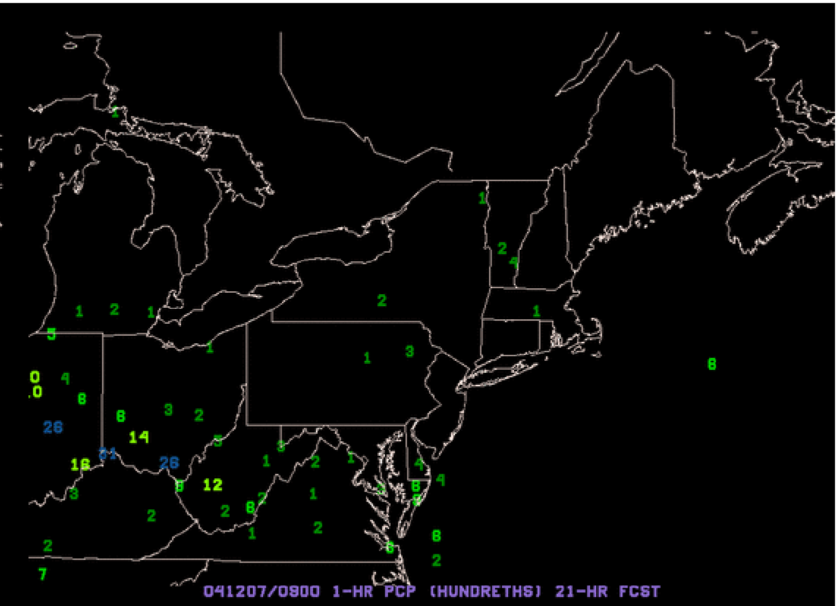


Soon to be added 2-D plots









SREF System Upgrade

Jeff McQueen, Jun Du, B. Zhou,
B. Ferrier, G. Manikin, E. Rogers
G. DiMego, H. Juang, Z. Toth, B. Bua

Previous NCEP SREF System

- Multi-model (Eta and RSM), multi-analysis (gdas and edas), multi-Ics (breeding) and multi-physics (BMJ, KF and SAS):
  - Eta_BMJ (5) -- ctl + 2 breeding pair from edas
  - Eta_KF (5) -- ctl + 2 breeding pair from edas
  - RSM_SAS (5) – ctl + 2 breeding pair from gdas

- 48km, 63h fcst, twice per day (09z and 21z), large NA domain with CONUS grib 212 output

- Grib data (NCEP centers), ftp and web (outsider users)
- Special products: aviation and summer NE energy project

- ***Two related problems:***
  - ***lack of spread due to clustering by model especially in summer***
  - ***IC perturbation size too small in summer while it can get too big in winter***

Upgraded NCEP SREF System 17 August 2004

- Six convective schemes: BMJ / SAT, KF / DET and SAS / RAS
  - Eta_BMJ (3): ctl + 1 breeding pair (BMJ = Betts-Miller-Janjic)
  - Eta_SAT (2): 1 breeding pair (modified saturated profiles within BMJ)

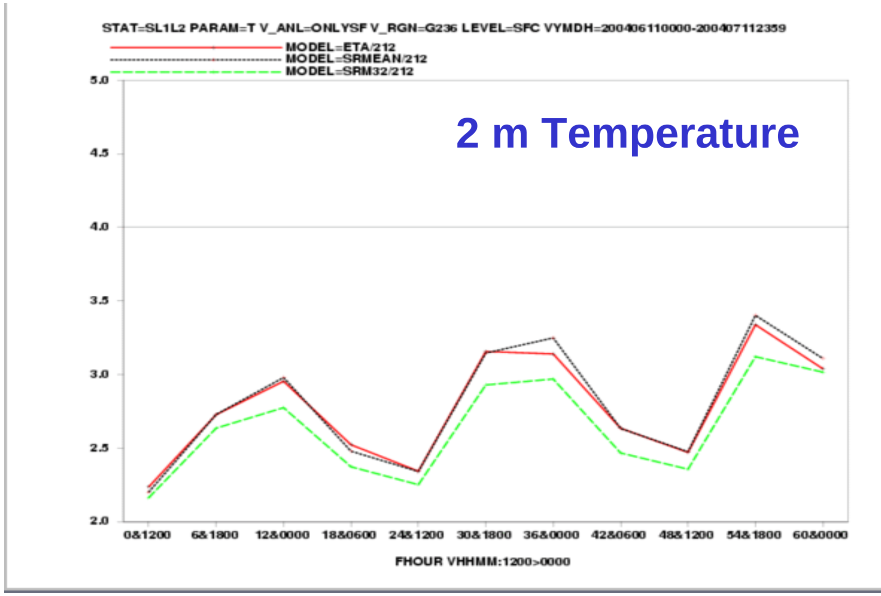
  - Eta_KF (3): ctl + 1 breeding pair (KF = Kain-Fritsch)
  - Eta_DET (2): 1 breeding pair (partial detrainment added to KF)

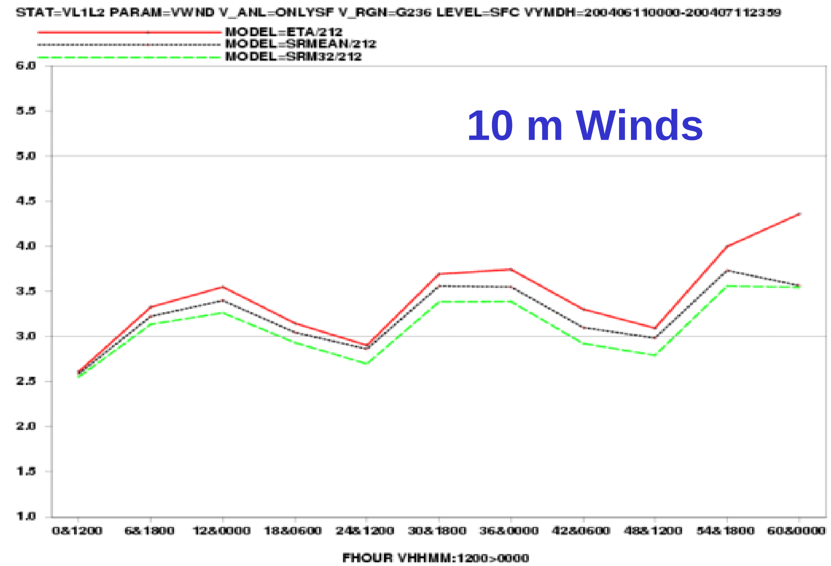
  - RSM_SAS (3): ctl + 1 breeding pair (SAS=simplified Arakawa-Schubert)
  - RSM_RAS (2): 1 breeding pair (RAS = relaxed Arakawa-Schubert)

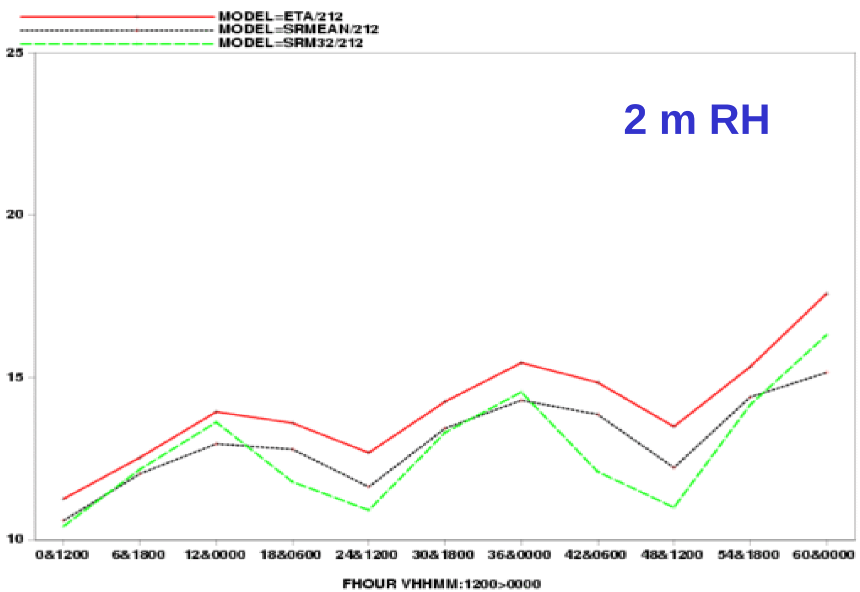
- New scaled breeding (prevents IC pert size from being too small in summer and from being too big in winter but always consistent with typical analysis error magnitude)
- Increase resolution from 48km to 32km (L45 to L60 for Eta)
- Up-to-date model codes & physics for both Eta and RSM
- Extended & Corrected SREF product output

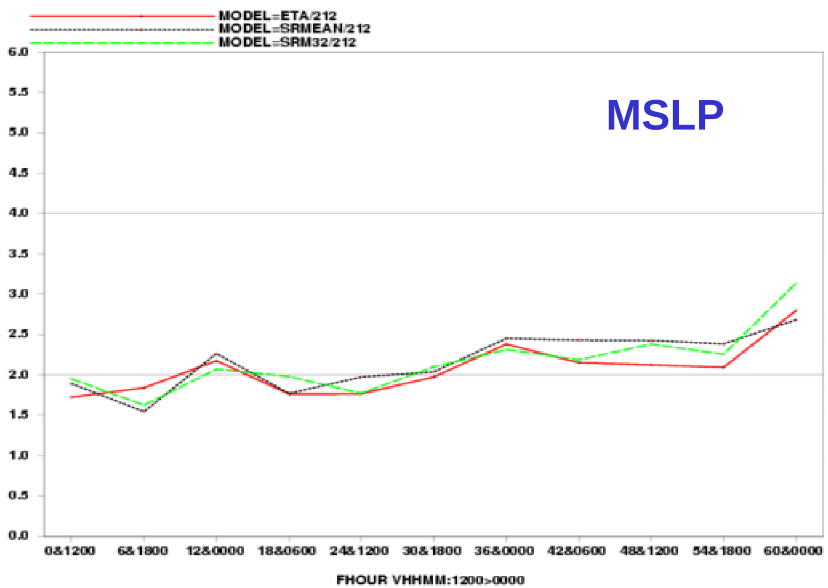
SREF Deterministic Results

Surface CONUS RMSE by Forecast hr (June 12-July 11, 2004)



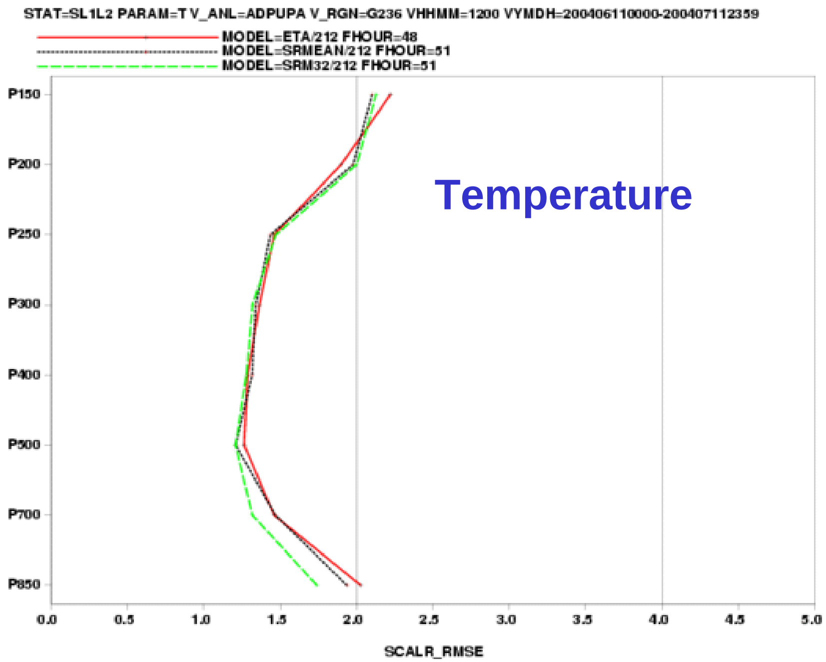


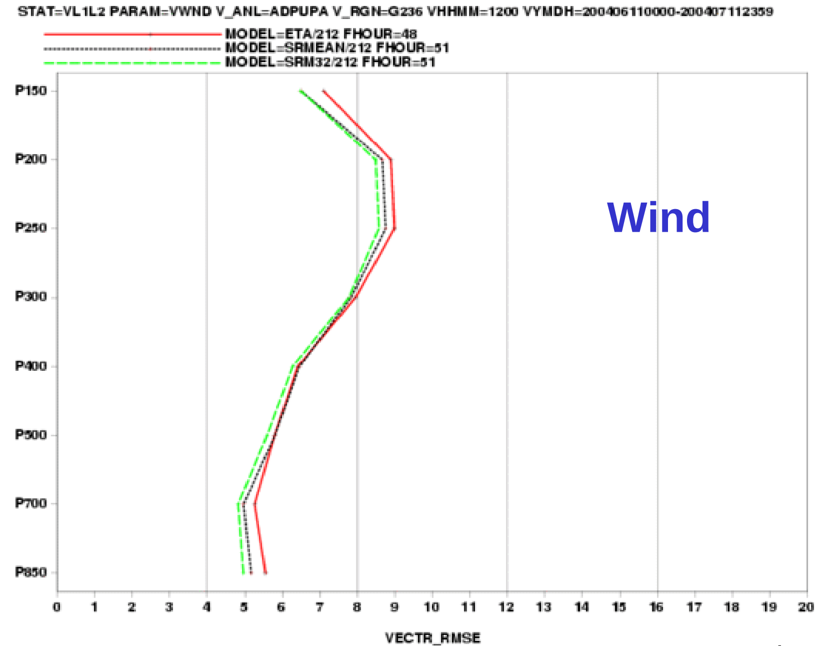


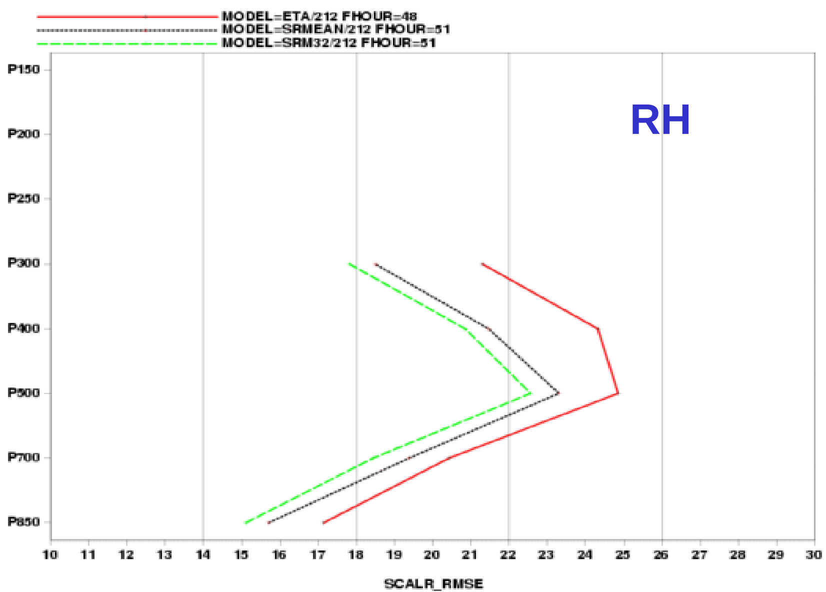


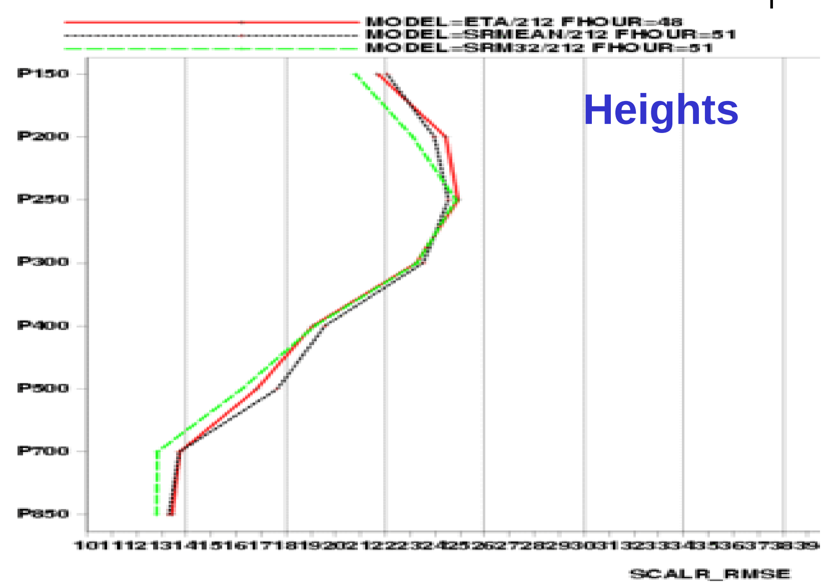
SREF Deterministic Results

Upper-Level 48 h RMSE (June 12-July 11, 2004)



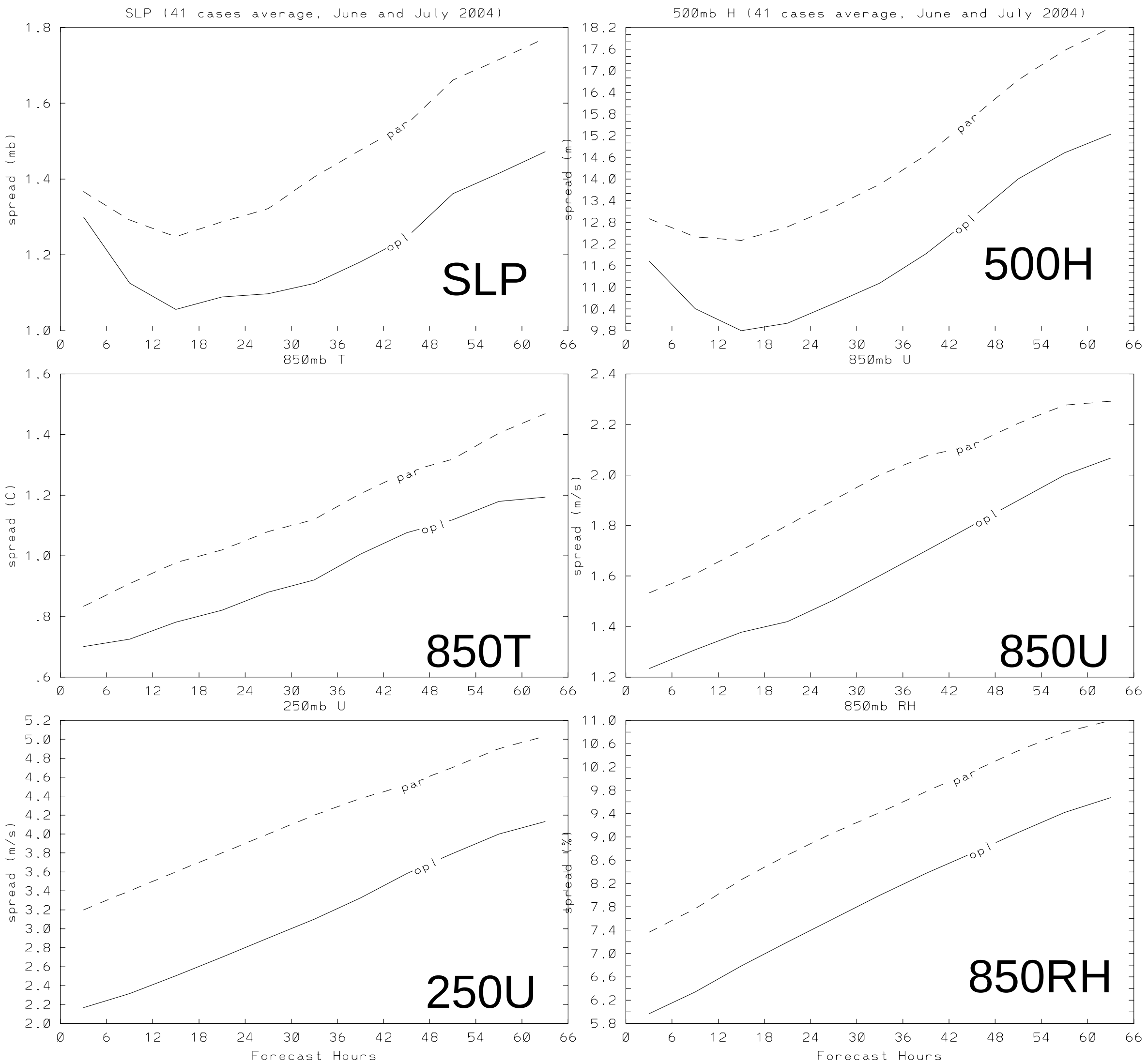






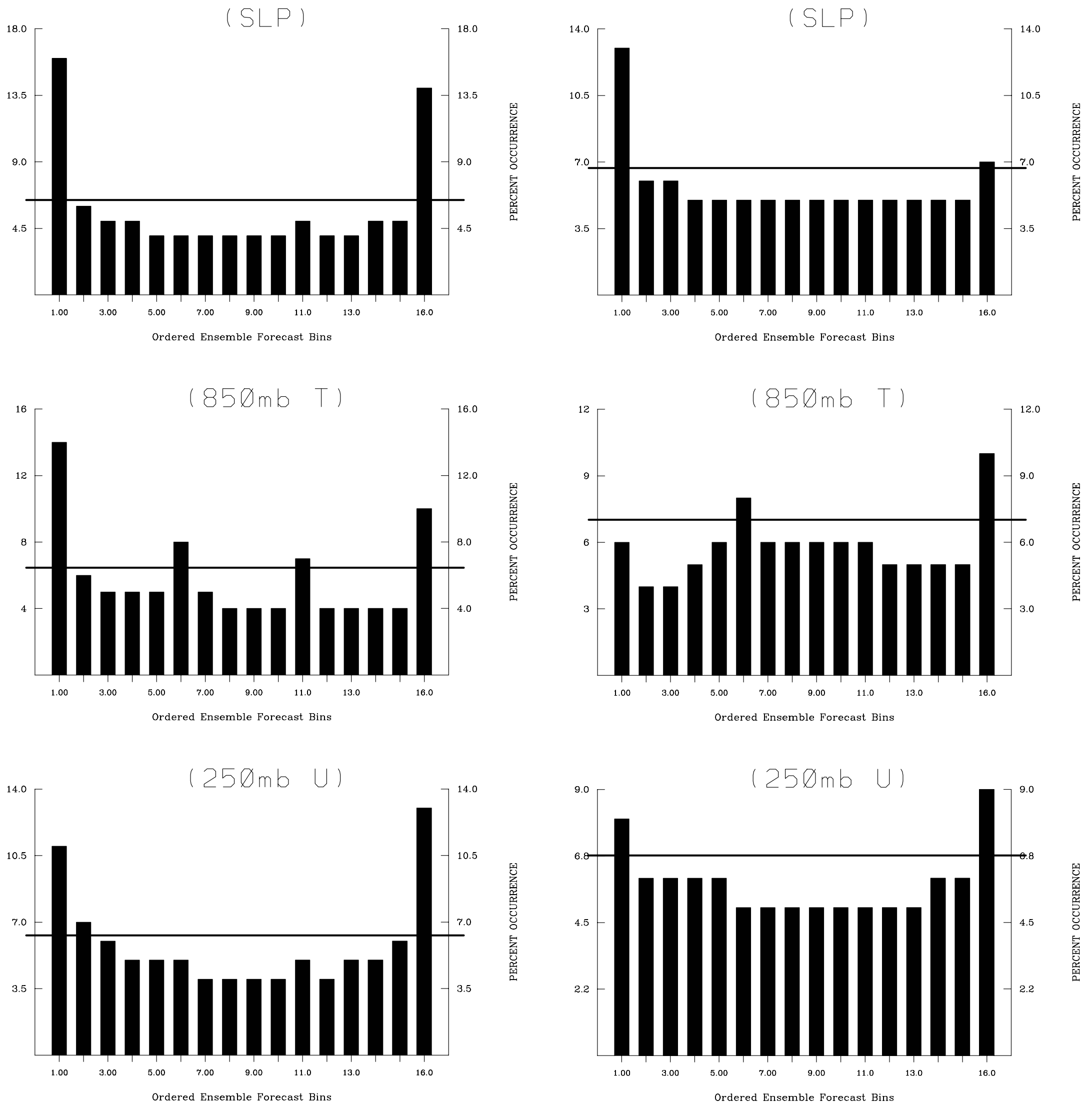
SREF Probabilistic Results

Spread Plots (June 12-July 11, 2004)



SREF Probabilistic Results

Ranked Histograms (June 12-July 11, 2004)

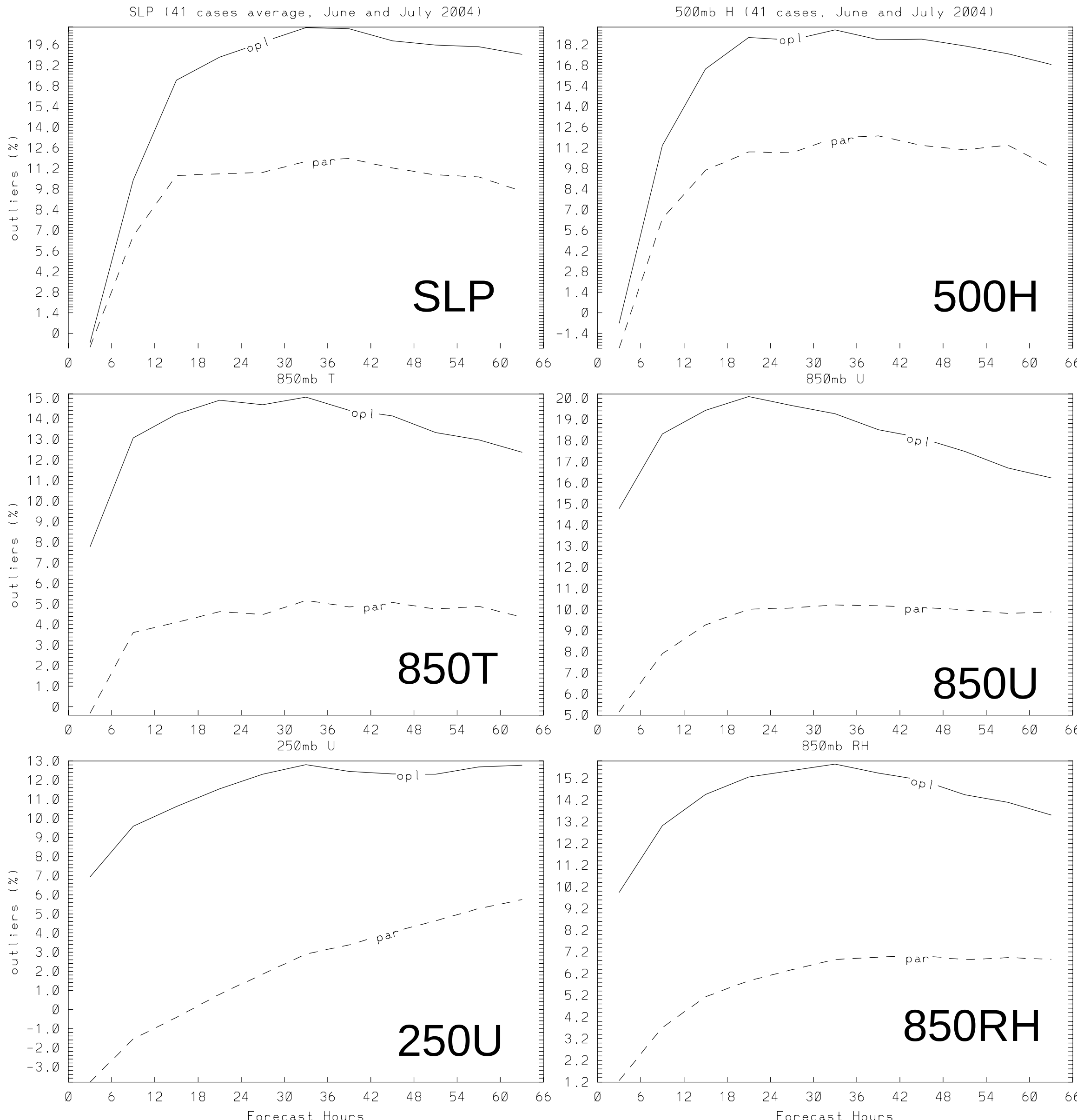


Operational **Experimental**

SREF Probabilistic Results

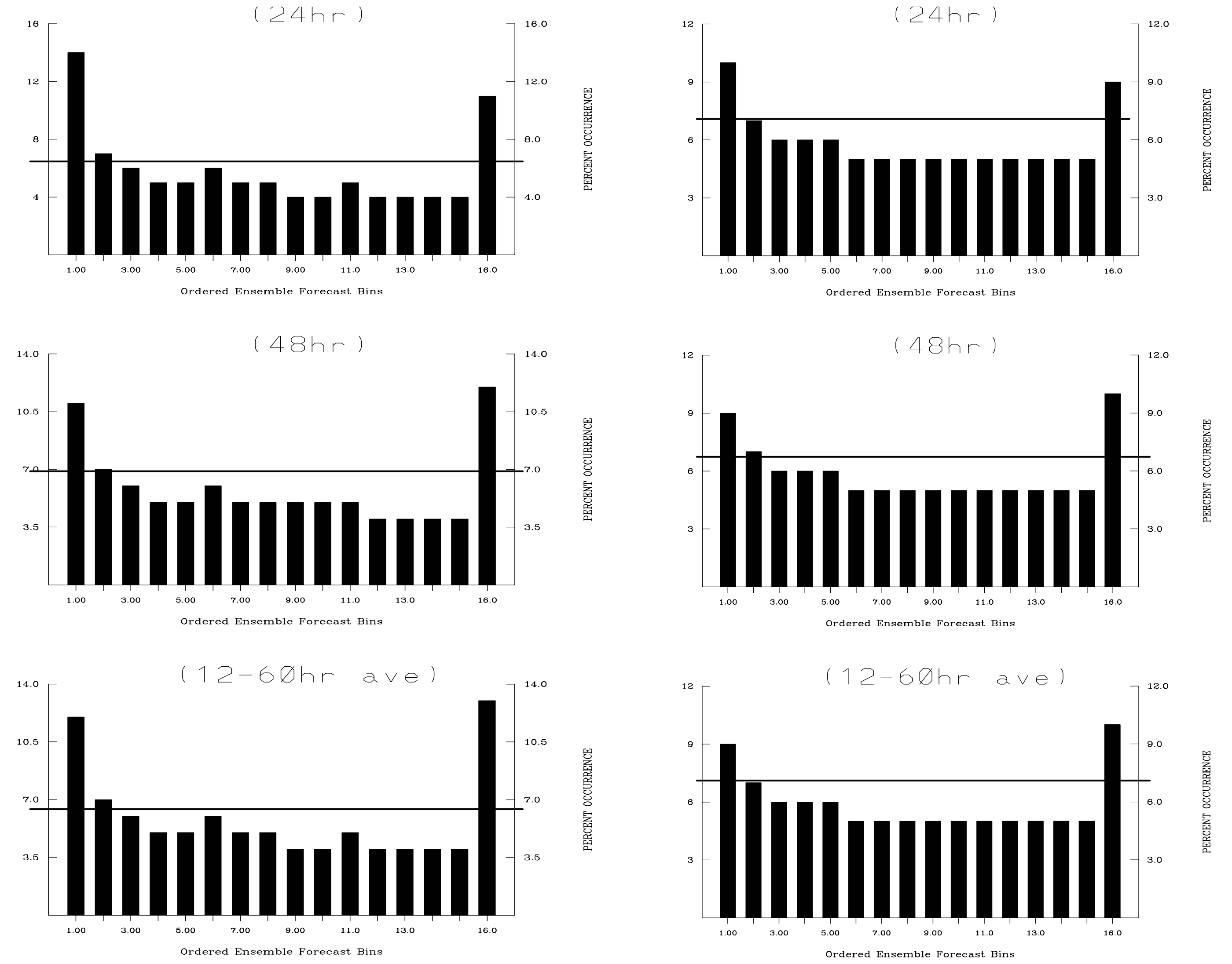
Outlier Plots (June 12-July 11, 2004)

Increased system spread results in fewer forecast outliers



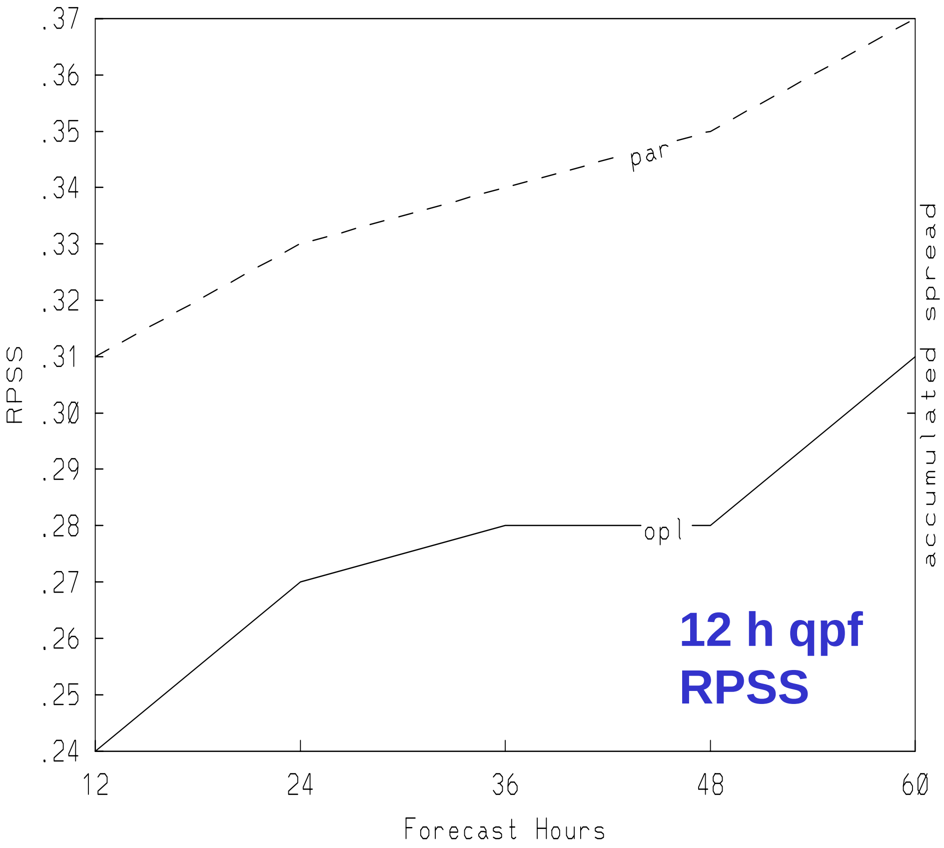
SREF Probabilistic Results

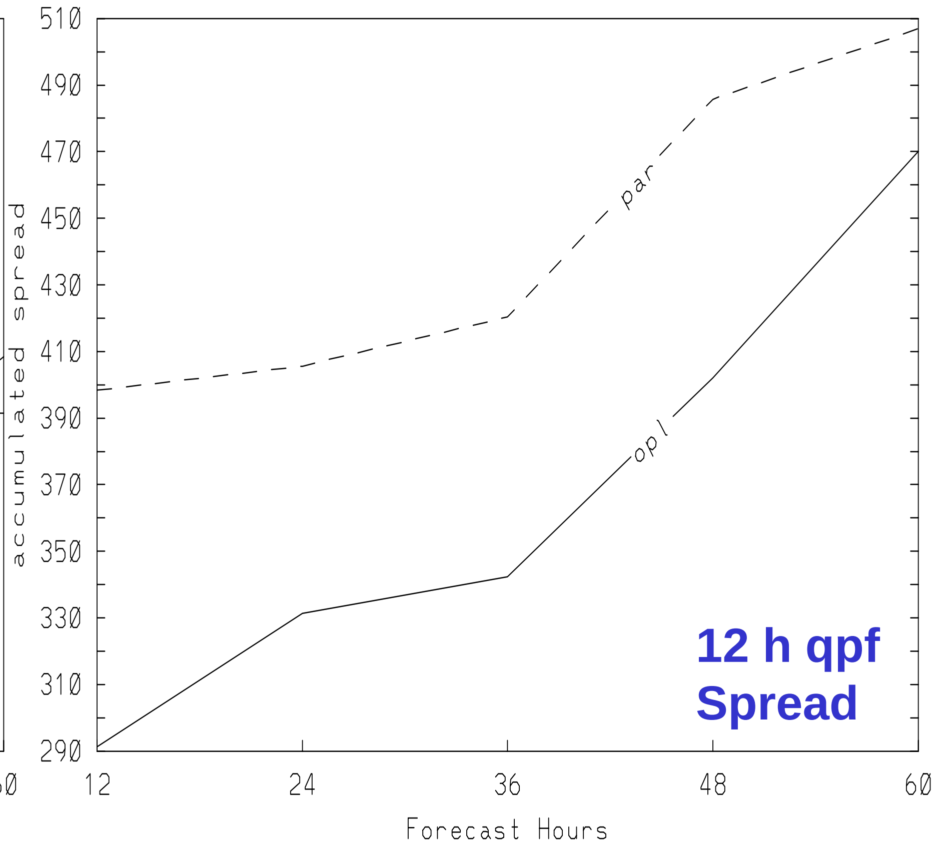
Precipitation Ranked Histograms *(June 12-July 11, 2004)*



Operational **Experimental**

SREF Probabilistic Results



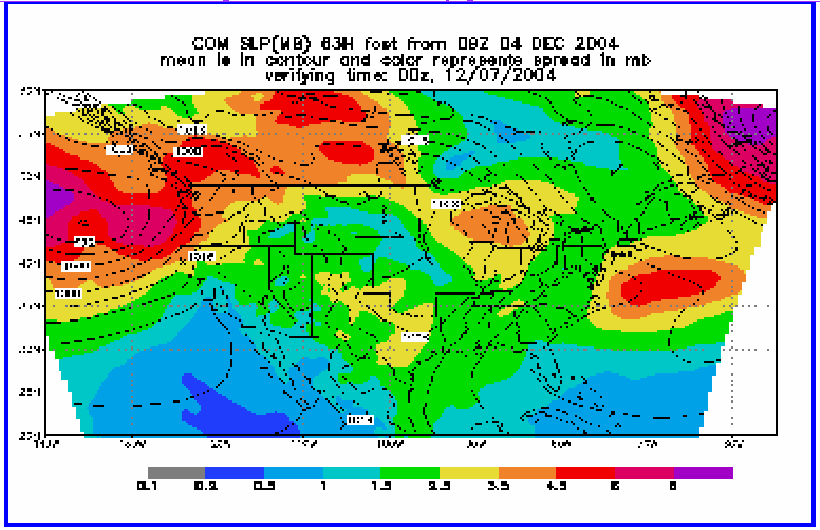


Subjective Evaluation

- AWC:
  - Performance improved, recommend implementation
- HPC:
  - Reduced clustering around parent model, increased diversity
  - Ensemble mean qpf is too noisy
  - Neutral, would have preferred more cold season cases
- SPC:
  - Improved physics diversity, reduced clustering
  - System spread and accuracy improvement quite impressive
  - Some members perform poorly for qpf
  - Recommend implementation
- TPC & OPC
  - SREF not used regularly

SHORT-RANGE ENSEMBLE FORECASTING (SREF)

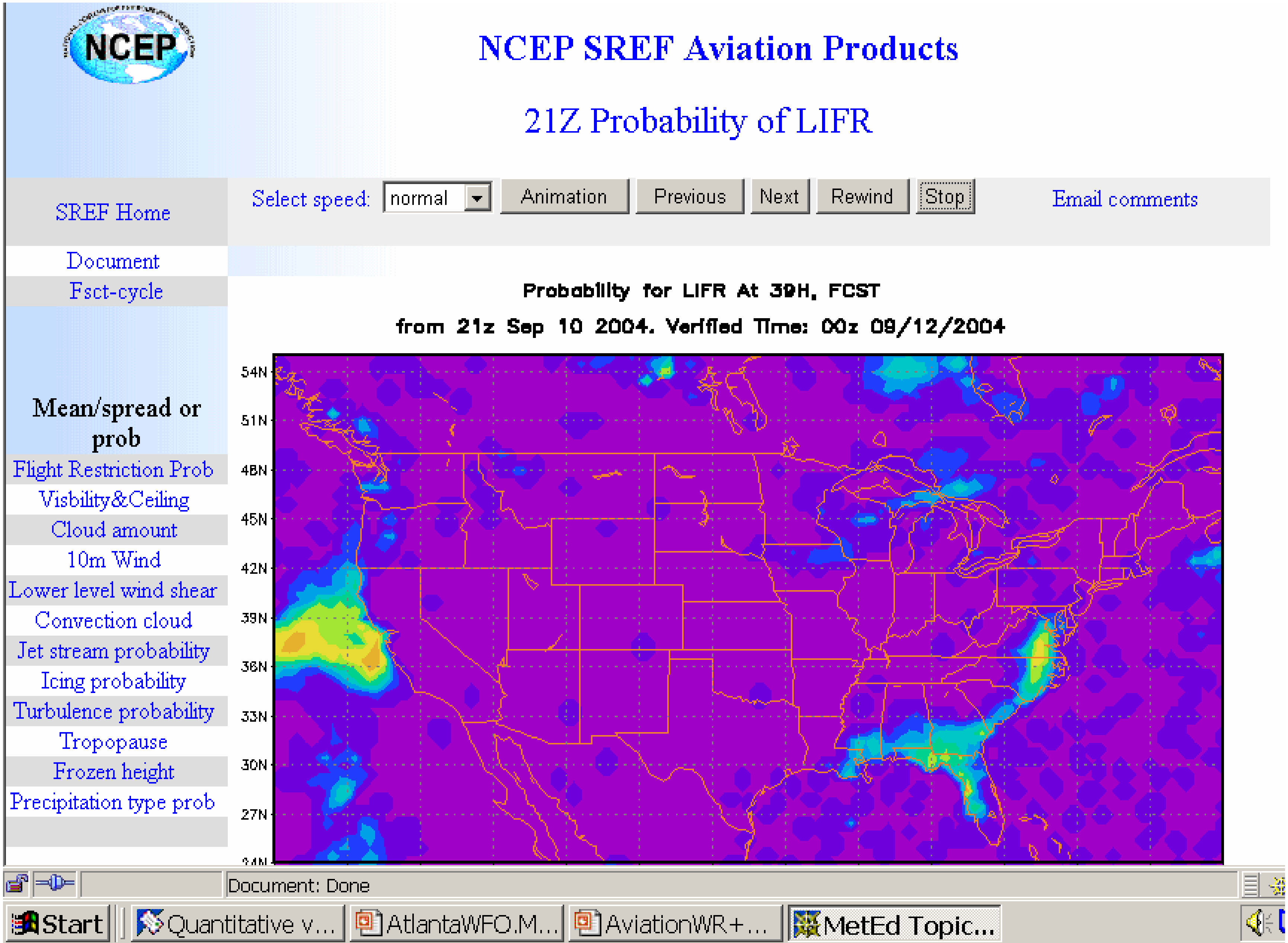
http://wwwt.emc.ncep.noaa.gov/mmb/SREF/SREF.html

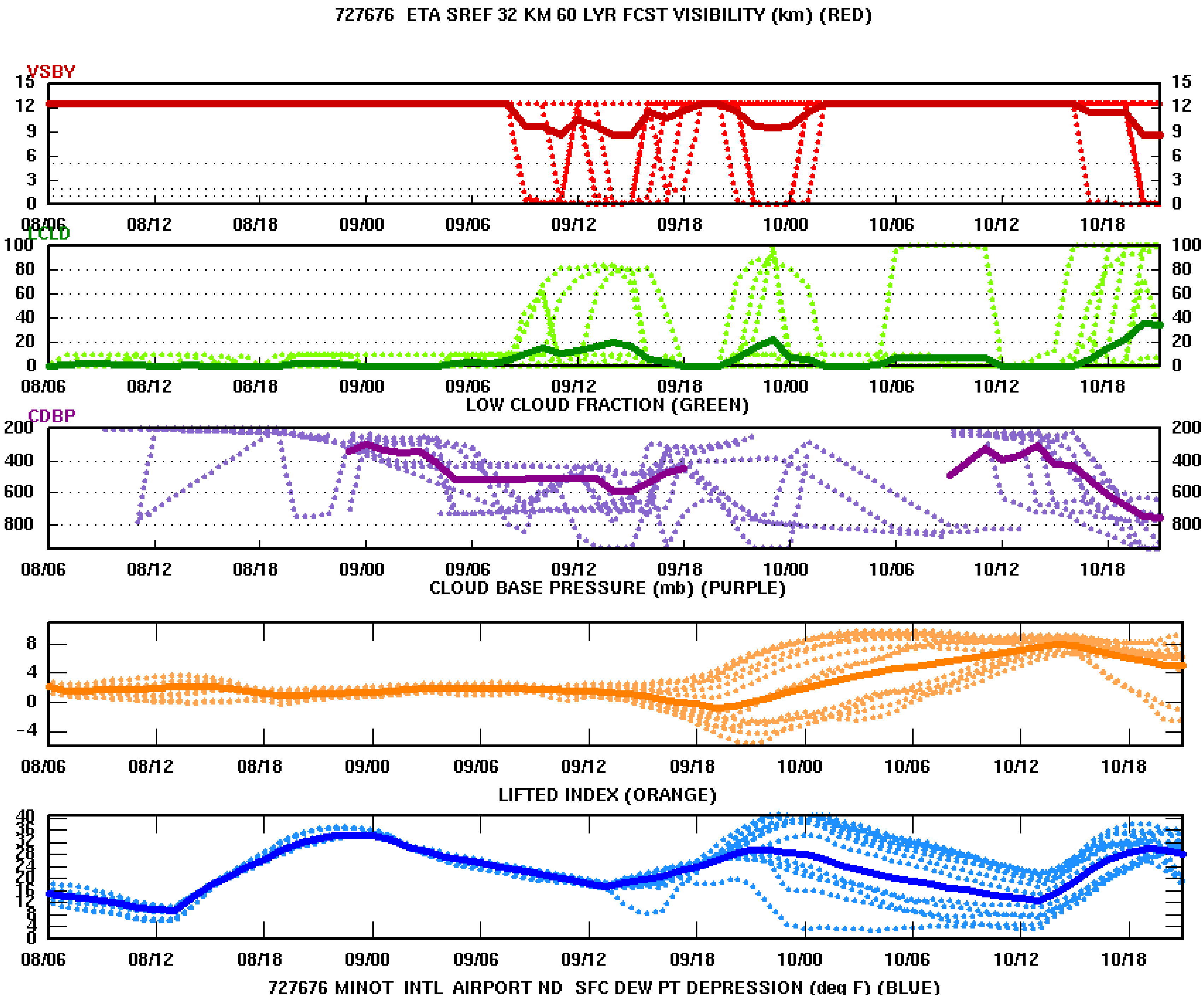


General Weather Forecasting (site A, animation & zooming)
General Weather Forecasting (site B, static, same products as A)
General Weather Forecasting (site C) No zooming(faster)   Zooming ability
SREF-based Meteograms for Selected Sites
SREF-based Cyclone/Hurricane Tracks
Specific Applications (Aviation, Hydrology, Energy and Fire Weather)
Current SREF Testing Site

Project Description	References	R&D Site	New Site
Case Study	SREF Training	Verification	Other Links

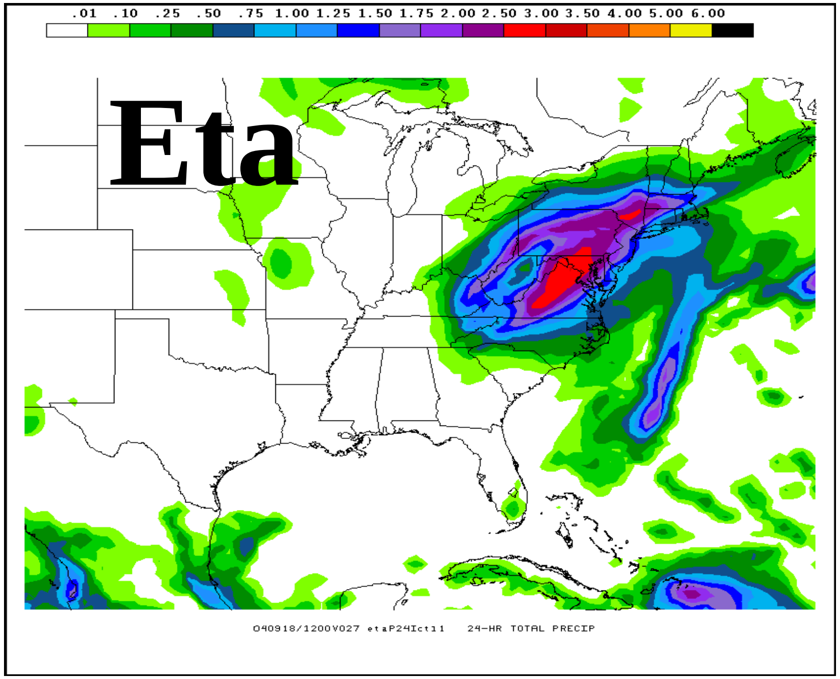
SREF Aviation Page

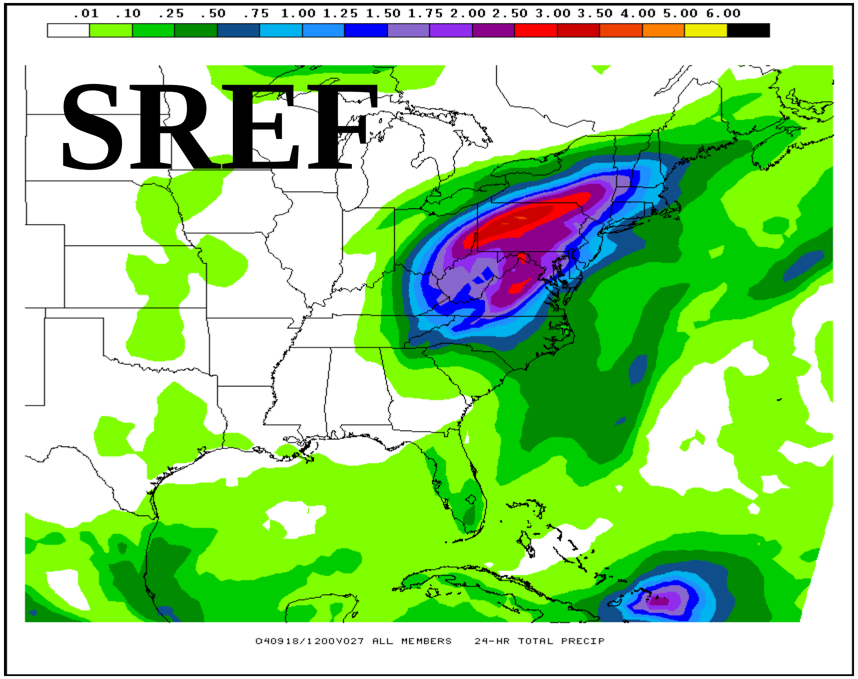


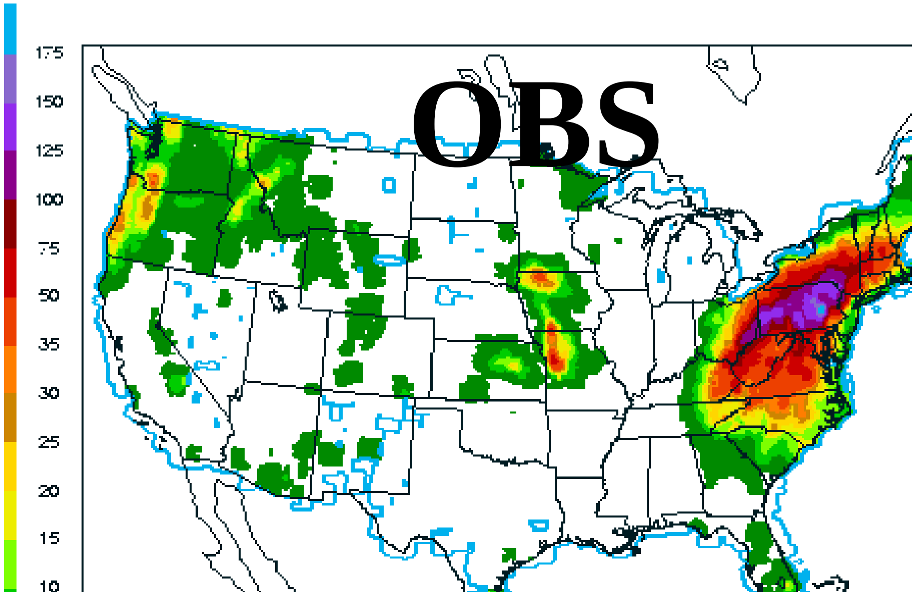


727676 ETA SREF 32 KM 60 LYR FCST VISIBILITY (km) (RED)
VSBY
15
12
9
6
3
0
08/06
08/12
08/18
09/00
09/06
09/12
09/18
10/00
10/06
10/12
10/18
LCLD
100
80
60
40
20
0
LOW CLOUD FRACTION (GREEN)
CDBP
200
400
600
800
CLOUD BASE PRESSURE (mb) (PURPLE)
8
4
0
-4
LIFTED INDEX (ORANGE)
40
0
727676 MINOT INTL AIRPORT ND SFC DEW PT DEPRESSION (deg F) (BLUE)

SREF Example courtesy of Geoff Manikin







Eta has heaviest rain over DC / Va due to too much warm sector convection leaving less moisture available for overrunning

SREF mean has the axis of heaviest precipitation slightly too far north and west, but it clearly gives the idea where heaviest amounts will occur with the overrunning region in PA.

Planned SREF Upgrades

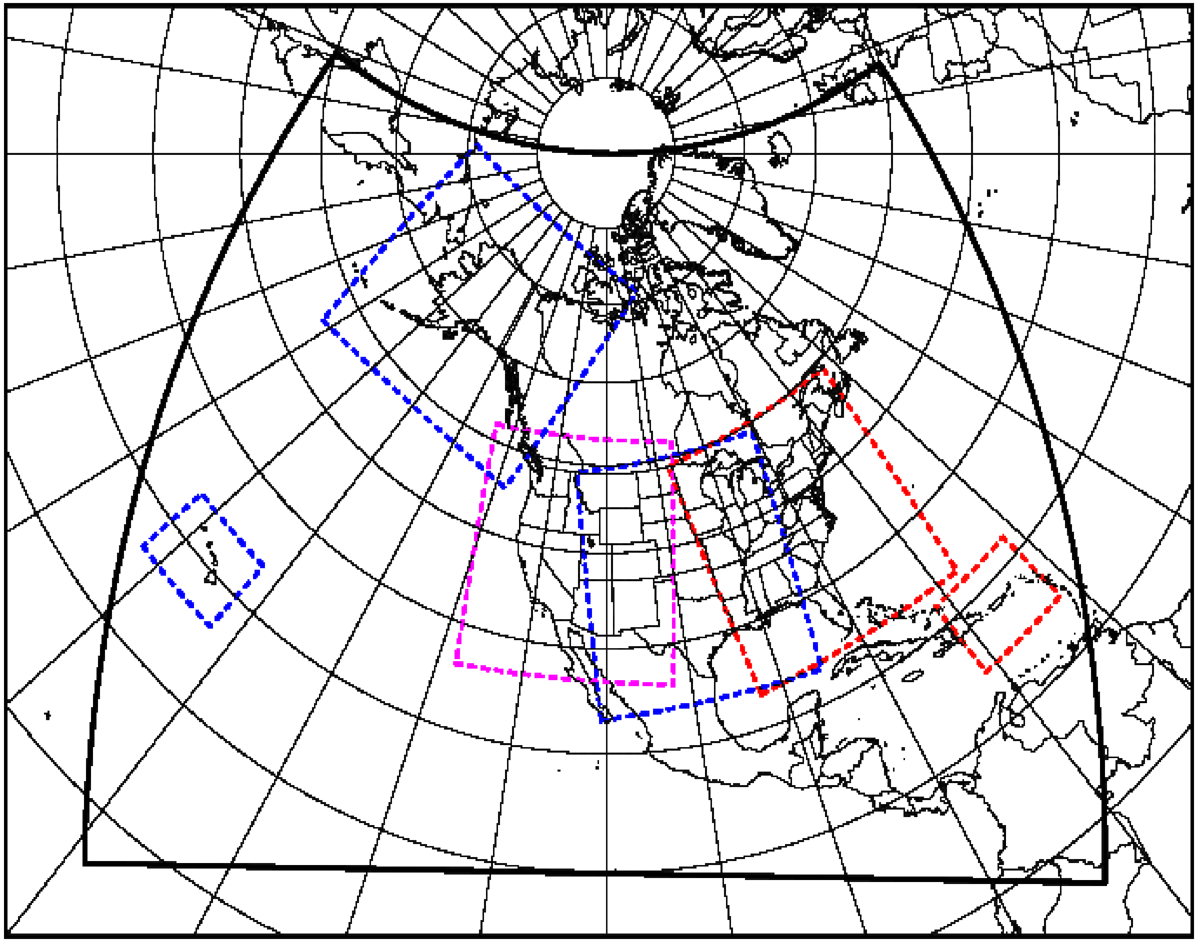
Fall 2005

- 4x/day runs
- Output for Alaska (AWIPS 216) & Hawaii (AWIPS 243)
- Grid Based Bias Correction
- Common WRF post-processor
- 5-6 WRF members
- Add RSM BUFR files
- Implement ensemble mean BUFR files
- Improved and new products (Convective, Aviation, Energy)
- Probabilistic FVS verification
- Confidence Factors (RMOP)

HiResWindow Fixed-Domain Nested Runs

21 September Became WRF Runs of Two Control Configurations

- Routine runs made at the same time every day
- 00Z : Alaska-8 & Hawaii-8
- 06Z : Western-8 & Puerto Rico-8
- 12Z : Central-8 & Hawaii-8
- 18Z : Eastern-8 & Puerto Rico-8
- Everyone gets a daily high resolution run when <2 hurricane runs need to be made



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

Alaska-8 domain is smaller than depicted

Weather Research and Forecasting (WRF)

- End-to-end Common Modeling Infrastructure
  - Observations and analysis
  - Prediction model
  - Post-processing, product generation and display
  - Verification and archive
- For the community to perform research
- For Operations to generate NWP guidance
- USWRP sponsorship - many partners: NCAR, NCEP, FSL, OU/CAPS, AFWA, FAA, NSF and Navy
- Initial implementation in HiResWindow in 4QFY04
- Ensemble approach to be taken instead of single-run deterministic approach

NCEP WRF Ensemble Design:

- NCEP CCS computer upgrade will be ~6x for weather
- Therefore, establish 6-member ensemble run in place of single deterministic HiResWindow run
  - 2 Control members
    - **NCEP NMM core & NCEP physics, Dx = 8 km**
    - **NCAR Mass core & NCAR physics, Dx = 10 km**
  - 4 Additional members
    - bred mode initial condition perturbations
    - SREF anomaly applied to lateral boundary condition
- Qualified cores and evaluated potential ensemble members according to the *WRF Test Plan (Nelson Seaman)*

Two cores currently in WRF Infrastructure

- **Eulerian Mass core V1.0 (Eulerian MC),**

  [V2.0 released May'03]

  - Terrain following hydrostatic mass-field vertical coordinate, arbitrary vertical resolution
  - Arakawa C-grid
  - Two-way nesting under evaluation
  - 3rd order Runge-Kutta time-split differencing
  - Conserves mass, momentum, dry entropy and scalars using 5th order (or 6th order) upwind spatial differencing to advect fluxes

- **Nonhydrostatic Mesoscale Model (NMM)**

  - Hybrid sigma-to-pressure terrain following vertical coordinate
  - Arakawa E-grid
  - Two-way nesting under develop'mt
  - Adams-Bashforth time differ'cing, time splitting
  - Conserves rotational kinetic energy, total energy, mass, enstrophy and momentum using 2nd order nine-point differencing for advection

Two WRF Physics Packages

- ***Eulerian Mass-Core:* NCAR physics package** (MM5 & Eta conversions) (w/options)

- NOAH unified 5-layer land-surface model
- Ferrier gridscale cloud and microphysics
- Kain-Fritsch convection
- Yong-Sei University PBL
- Dudhia shortwave
- RRTM longwave
- [Also adapted to use NCEP physics]

- ***NMM Core*: NCEP physics package** (NMM = modified Eta)

- NOAH unified 5-layer land-surface model
- Ferrier gridscale cloud and microphysics
- Betts-Miller-Janjic convection
- Mellor-Yamada-Janjic 2.5 PBL
- Lacis-Hansen shortwave
- Fels-Schwartzkopf longwave
- [Also adapted to use NCAR physics]

Evaluation Studies: The WRF Test Plan

Purpose: **Rigorously evaluate principal configurations of WRF** to validate model for future research and operations.

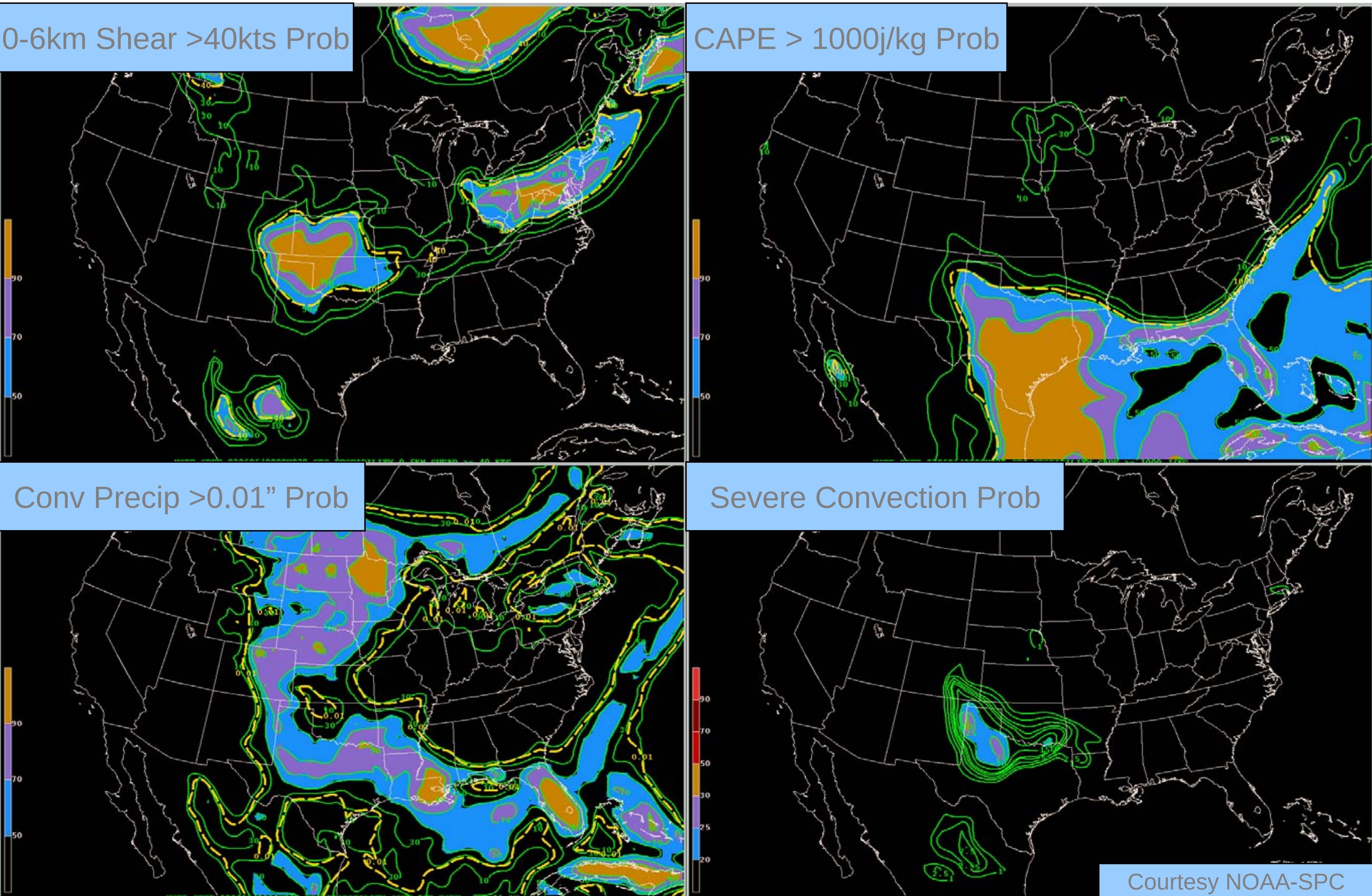
Results: NCEP will select six members for its **initial WRF ensemble** in Hi-Resolution Windows from **eight options** run under the WRF Test Plan:

- **2 Control members:**
  - WRF-NMM with NMM physics and Eta IC/BCs
  - WRF-MC with NCAR physics, RUC ICs, Eta BCs
- **2 Cross-bred physics members:**
  - WRF-NMM with NCAR physics and Eta IC/BCs
  - WRF-MC with NMM physics , RUC ICs, Eta BCs
- **2 WRF NMM runs**, like NMM control, but with positive and negative **bred perturbations.**
- **2 WRF MC runs**, like MC control, but with positive and negative **bred perturbations.**

The WRF Test Plan: A collaboration of AFWA, NAVO, FSL, NCAR and NCEP for 1936 runs covering all seasons and 4 domains at 8 km

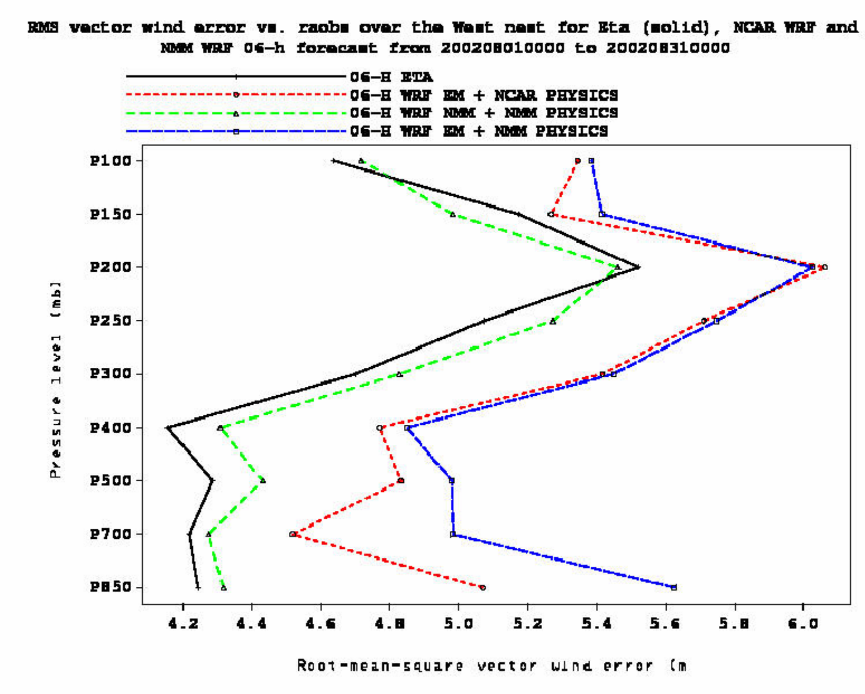
Month/ Year & Source	U.S. Hi-Resol. Domains	WRF-EM & NCAR Physics	WRF-EM & NCEP Physics	WRF-EM & NCAR Phys + perturba.	WRF-EM & NCAR Phys - perturba.	WRF-NM & NCEP Physics	WRF-NM & NCAR Physics	WRF-NM & NCEP Physics + perturba	WRF-NM & NCEP Physics +- perturba
Feb ’03 FSL	East	28/28	28/28	28/28	28/28	28/28	28/28	28/28	28/28
Feb ’03 FSL	West	28/28	28/28	28/28	28/28	28/28	28/28	28/28	28/28
May’03 AFWA	Central	31/31	31/31	31/31	31/31	31/31	31/31	31/31	31/31
May’03 AFWA	East	31/31	31/31	31/31	31/31	31/31	31/31	31/31	31/31
Aug’03 AFWA	Central	31/31	31/31	31/31	31/31	31/31	31/31	31/31	31/31
Aug’03 AFWA	West	31/31	31/31	31/31	31/31	31/31	31/31	31/31	31/31
Oct ’03 AFWA	East	31/31	31/31	31/31	31/31	31/31	31/31	31/31	31/31
Oct ’03 AFWA	Alaska	31/31	31/31	31/31	31/31	31/31	31/31	31/31	31/31

Example of Ensemble Probability Product

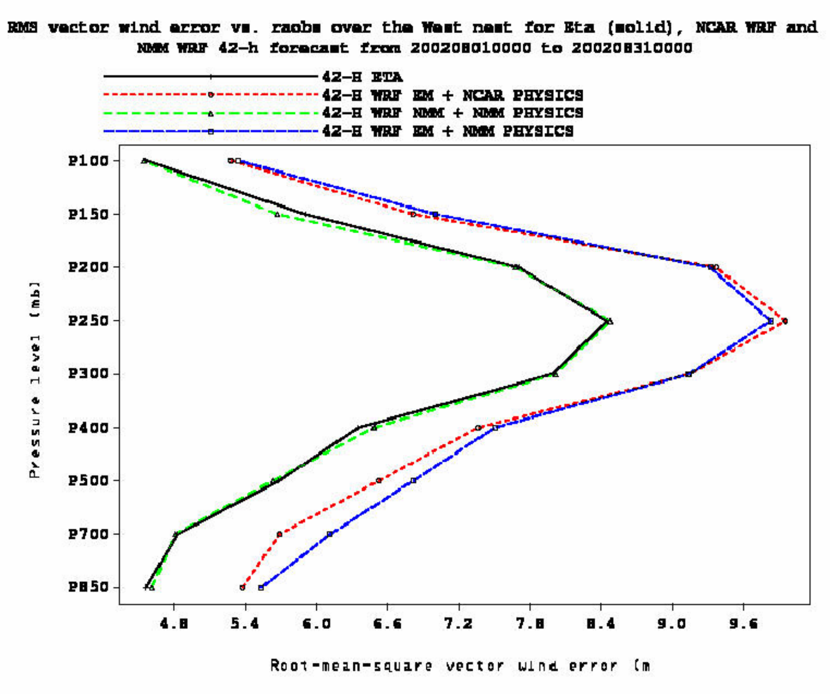


WRF Test Plan Evaluations: Average RMSE for Wind Speed vs. Pressure August 2002

6-h Forecast, West Domain



42-h Forecast, West Domain

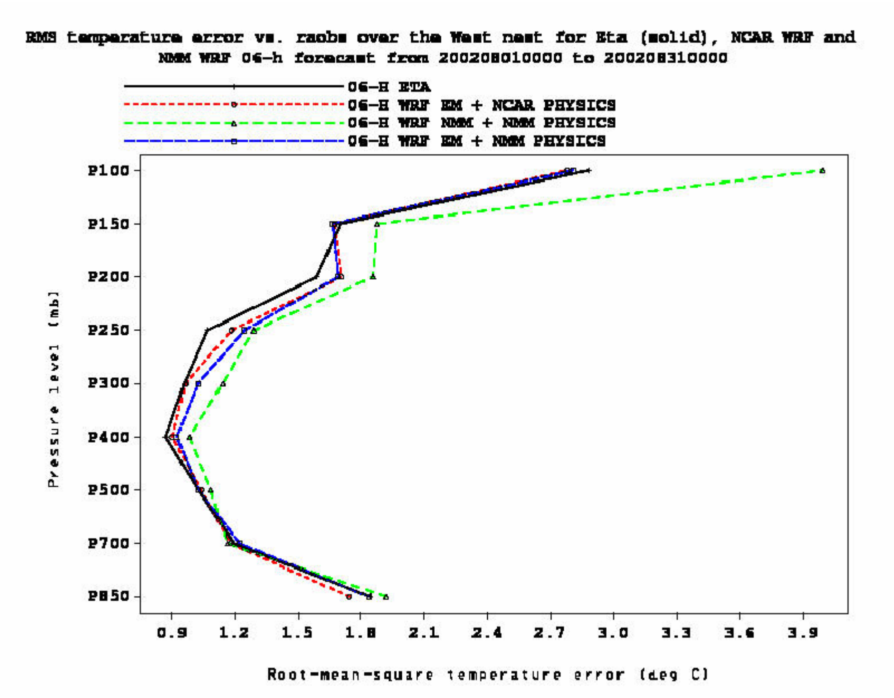


Operational Eta	WRF-NMM, NCEP Physics
WRF-MC, NCAR Physics	WRF-MC, NCEP Physics

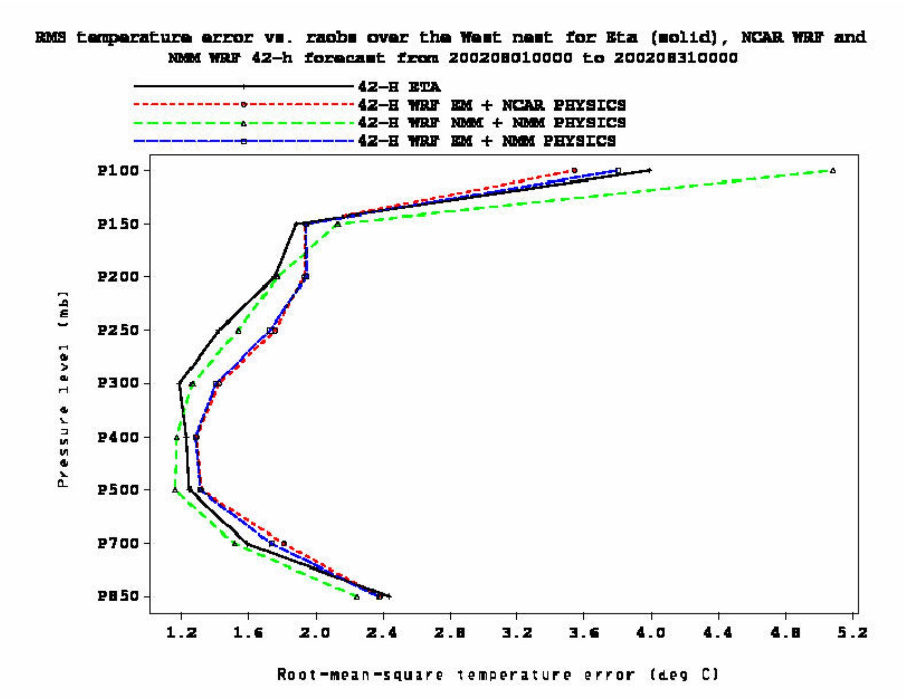
http://wwwt.emc.ncep.noaa.gov/mmb/WRFretro/html/test.html

WRF Test Plan Evaluations: Average RMSE for Temperature vs. Pressure August 2002

6-h Forecast, West Domain



42-h Forecast, West Domain



Operational Eta	WRF-NMM, NCEP Physics
WRF-MC, NCAR Physics	WRF-MC, NCEP Physics

http://wwwt.emc.ncep.noaa.gov/mmb/WRFretro/html/test.html

Verification Statistics for the NCEP WRF Pre-implementation Test: Part 2 Ensemble Results

Geoffrey DiMego, Marina Tsidulko, Hui-Ya Chuang, Keith Brill, and S. Gopalakrishnan
NOAA/NWS/NCEP/Environmental Modeling Center, Camp Springs, MD

Louisa Nance
Development Testbed Center
National Center for Atmospheric Research, Boulder, CO

Ligia Bernardet and Andy Loughe
NOAA/OAR/Forecast Systems Laboratory, Boulder, CO

Chris Davis
National Center for Atmospheric Research, Boulder, CO

Dan Lohaus and Frank Olson,
Northrup-Grummann, Inc., at Air Force Weather Agency, Offutt AFB, NB

The Remainder of the Developmental Testbed Center Team

P U R P O S E

- Combine various groups of the 8 retrospective runs into ensembles
- Evaluate ensembles
  - Verify mean using deterministic scores
  - Verify using ensembles scores
- Choose best 6 member combination

Eight WRF Retrospective Runs

- Four Physics Diversity (PD) runs of WRF Ensemble:
  - Initial conditions
    - RUC for WRF-MC runs
    - Eta for WRF-NMM runs
  - Crossbred physics
    - WRF-MC run with NCAR & NCEP physics
    - WRF-NMM run with NCEP & NCAR physics
  - Lateral boundary conditions from Eta
- Four Initial Perturbation (IP) runs of WRF Ensemble:
  - Initial condition breeding cycle produces a *pair of runs* for each core
    - WRF-MC with NCAR physics and RUC base initial conditions
    - WRF-NMM with NCEP physics and Eta base initial conditions
  - Apply 4 SREF based anomalies to Eta Lateral boundary conditions

WRF Ensemble Processing

- Based on NCEP experience with SREF, the five state variables (u, v, T, q and Ps), are perturbed
- Accomplished within the WRF common modeling infrastructure via a single utility - diffwrf
- Given three input files: File0 (the base field), File1 and File2, the general functionality of diffwrf can be written

$$\begin{bmatrix}\text{Modified} \\ \text{variable} \\ \text{in File0}\end{bmatrix} = \begin{bmatrix}\text{Original} \\ \text{variable} \\ \text{in File0}\end{bmatrix} + \alpha \begin{bmatrix}\text{variable - variable} \\ \text{in File1} \quad \text{in File2}\end{bmatrix}$$

Initial Condition Breeding Cycle

- Required modification of WRF restart file processing.
- File1 and File2 are forecasts made from a pair (+/-) of perturbed states from previous cycle.
- The factor, α, depends on the domain-averaged magnitude of the difference field.
- Rescaling ($\alpha < 1$) is only done if the magnitude is larger than a prescribed value (~ analysis error standard deviation) following procedures developed for NCEP's medium-range ensemble forecast system (Toth and Kalnay, 1997).
- The breeding cycle involves adding scaled perturbations in positive and negative sense from the pair of 24 hours forecast onto initial conditions of the next cycle yielding 2 runs from each control.

Lateral Boundary Condition Anomaly

- WRF-SI outputs and NeTCDF variables modified
- File1 and File2 are forecasts made from a perturbed state and the control of NCEP's SREF (basically the SREF member's anamoly with respect to its control run)
- The factor, α, is usually set to 1

Breeding Pairs with LBC Anomalies

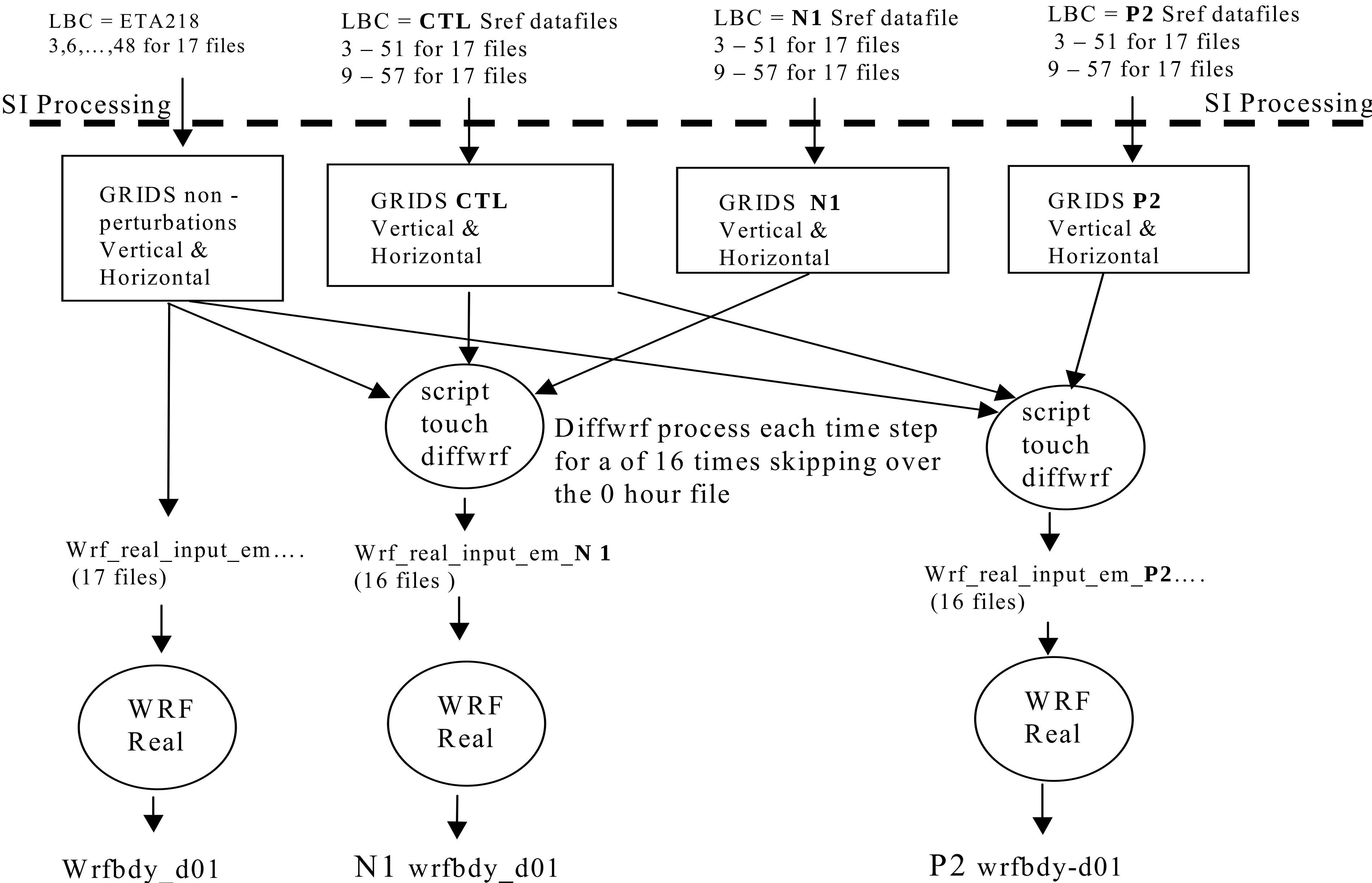
- Lateral boundary condition anomaly applied to WRF-SI's vinterp NeTCDF outputs using 4 SREF forecasts, namely, p1, p2, n1 and n2 and the control applied to either Eta12 or RUC initial condition forecast, yielding 4 perturbed forecasts, i.e.,

$$\left.\begin{array}{l} eta12 = eta12 + \alpha\,[p1 - ct1] \\ eta12 = eta12 + \alpha\,[n2 - ct1] \end{array}\right\} \rightarrow \text{NMM core}$$

$$\left.\begin{array}{l} eta12 = eta12 + \alpha\,[p2 - ct1] \\ eta12 = eta12 + \alpha\,[n1 - ct1] \end{array}\right\} \rightarrow \text{Mass core}$$

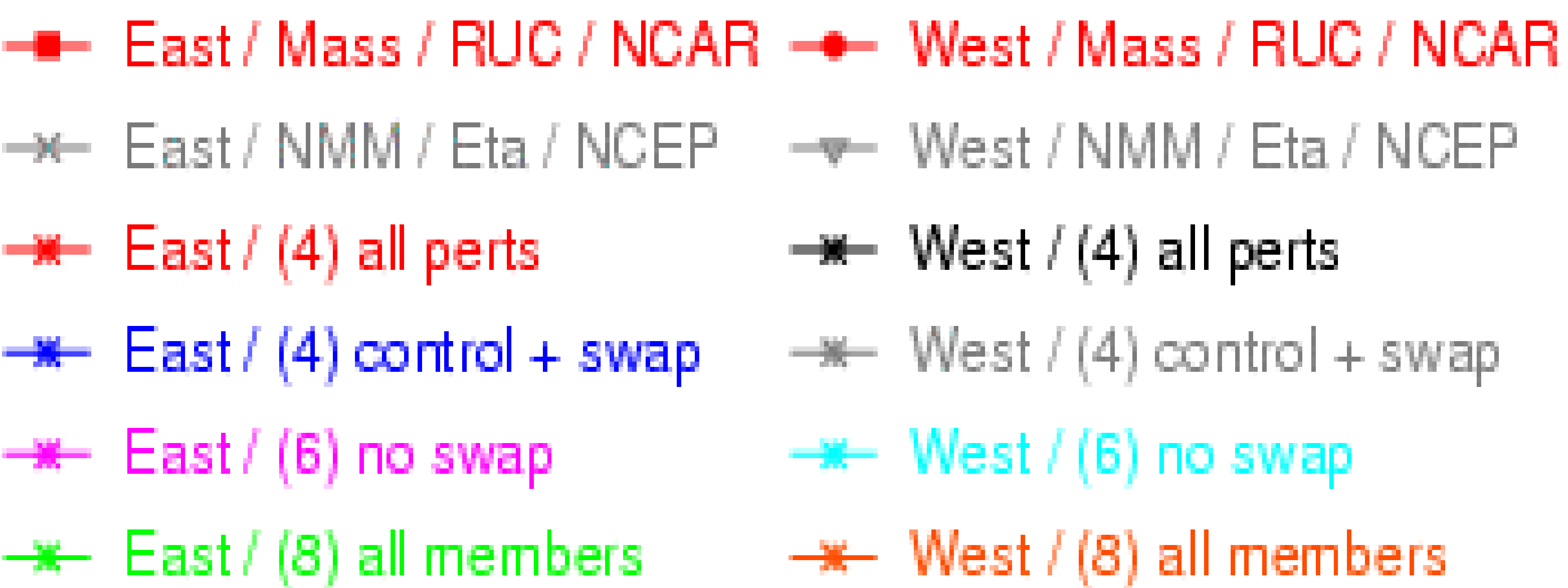
WRF Ensemble Processing

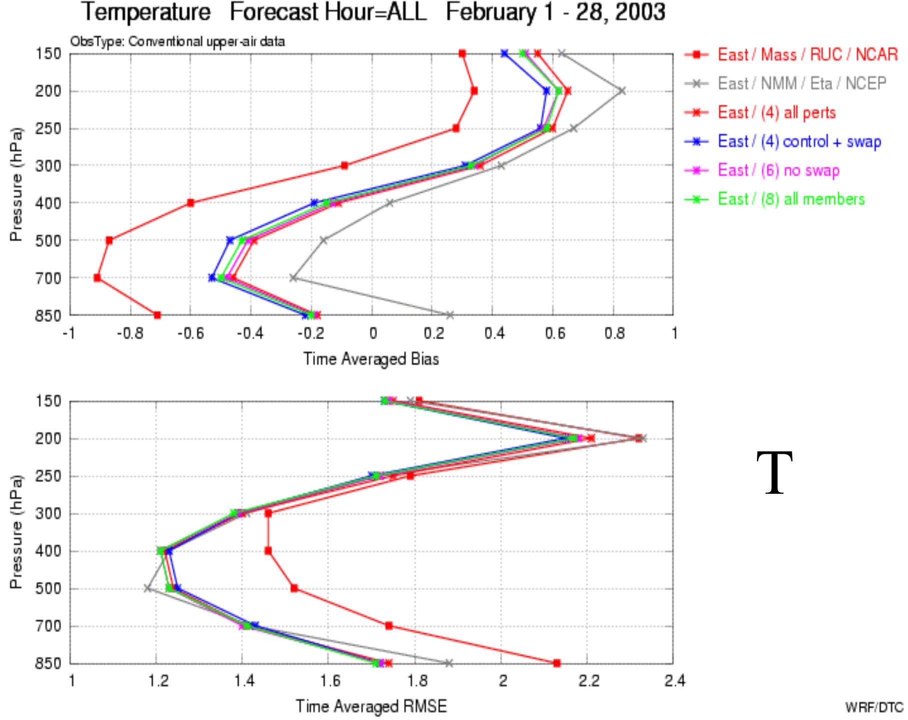
Breeding – Perturbation Data Flow -- Schematic

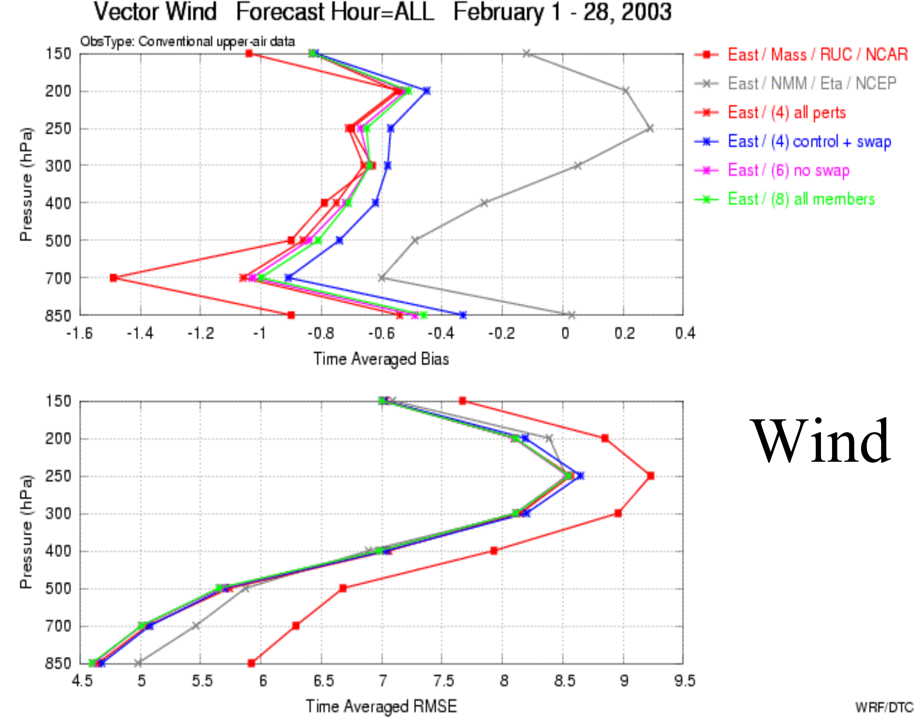


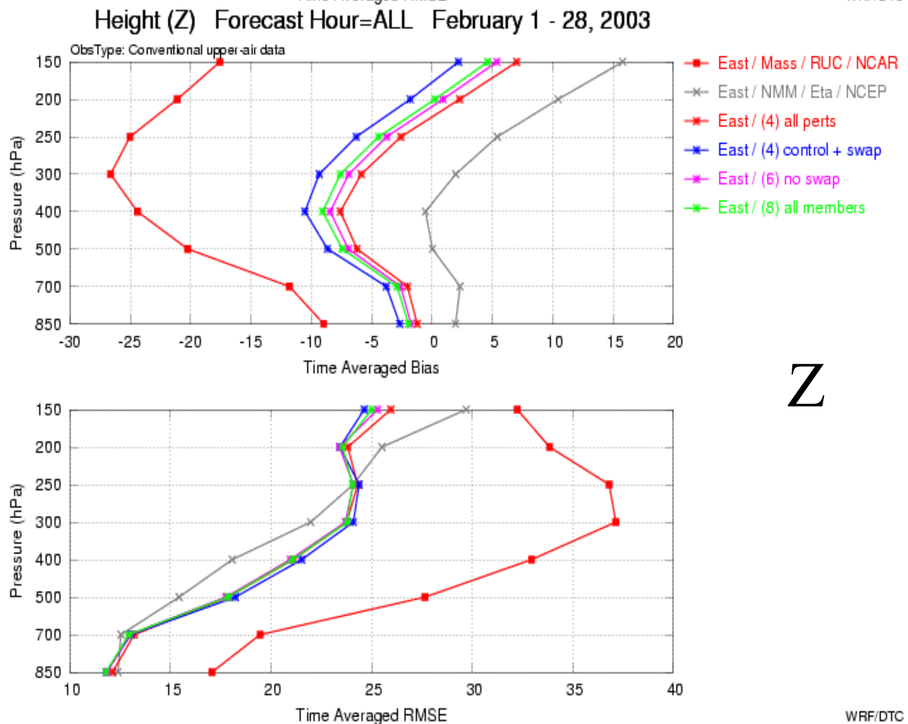
Deterministic Verification of Ensemble Means Versus Radiosonde Obs

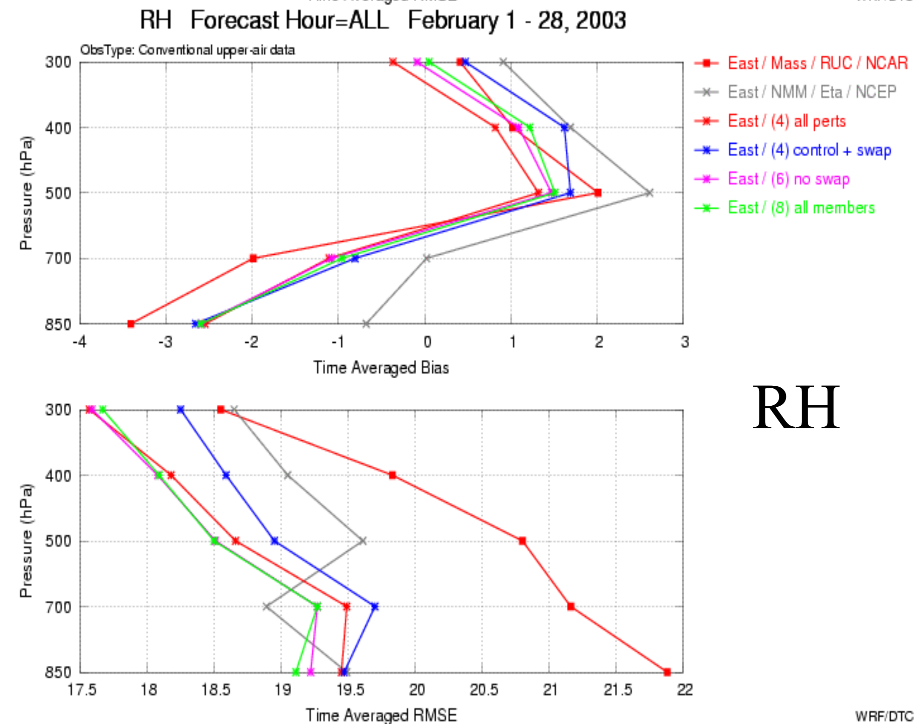
Color Codes

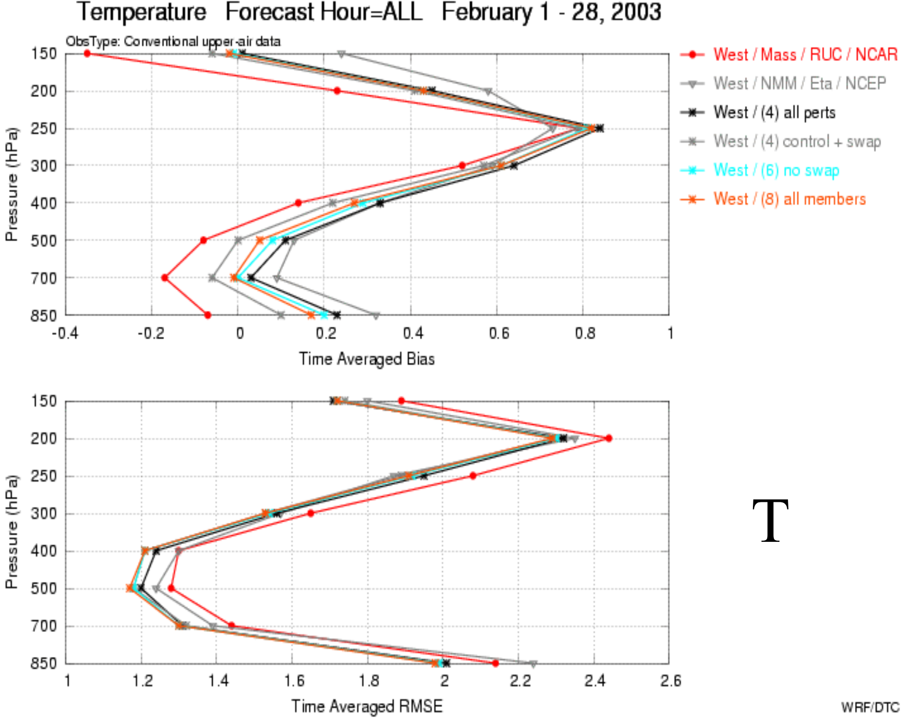



Temperature Forecast Hour=ALL February 1 - 28, 2003
ObsType: Conventional upper-air data
East / Mass / RUC / NCAR
East / NMM / Eta / NCEP
East / (4) all perts
East / (4) control + swap
East / (6) no swap
East / (8) all members
Pressure (hPa)
Time Averaged Bias
Time Averaged RMSE
T
WRF/DTC


Vector Wind Forecast Hour=ALL February 1 - 28, 2003
ObsType: Conventional upper-air data
East / Mass / RUC / NCAR
East / NMM / Eta / NCEP
East / (4) all perts
East / (4) control + swap
East / (6) no swap
East / (8) all members
Pressure (hPa)
Time Averaged Bias
Time Averaged RMSE
Wind
WRF/DTC

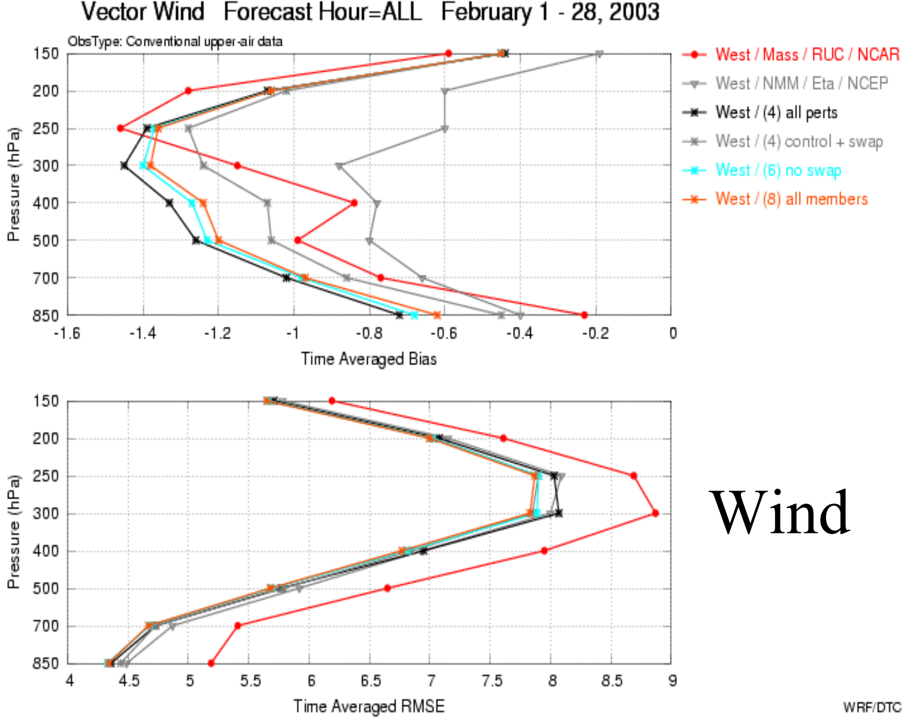

Height (Z) Forecast Hour=ALL February 1 - 28, 2003
ObsType: Conventional upper-air data
East / Mass / RUC / NCAR
East / NMM / Eta / NCEP
East / (4) all perts
East / (4) control + swap
East / (6) no swap
East / (8) all members
Pressure (hPa)
Time Averaged Bias
Time Averaged RMSE
Z
WRF/DTC


RH Forecast Hour=ALL February 1 - 28, 2003
ObsType: Conventional upper-air data
East / Mass / RUC / NCAR
East / NMM / Eta / NCEP
East / (4) all perts
East / (4) control + swap
East / (6) no swap
East / (8) all members
Pressure (hPa)
Time Averaged Bias
Time Averaged RMSE
RH
WRF/DTC



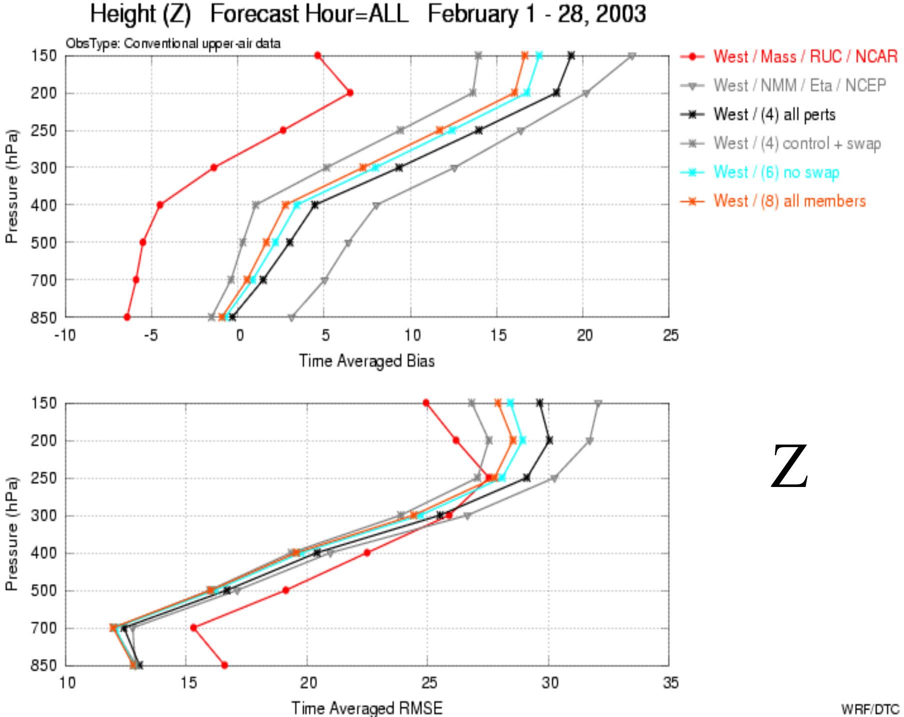
Temperature Forecast Hour=ALL February 1 - 28, 2003
ObsType: Conventional upper-air data
West / Mass / RUC / NCAR
West / NMM / Eta / NCEP
West / (4) all perts
West / (4) control + swap
West / (6) no swap
West / (8) all members
Pressure (hPa)
Time Averaged Bias
Time Averaged RMSE
WRF/DTC

T



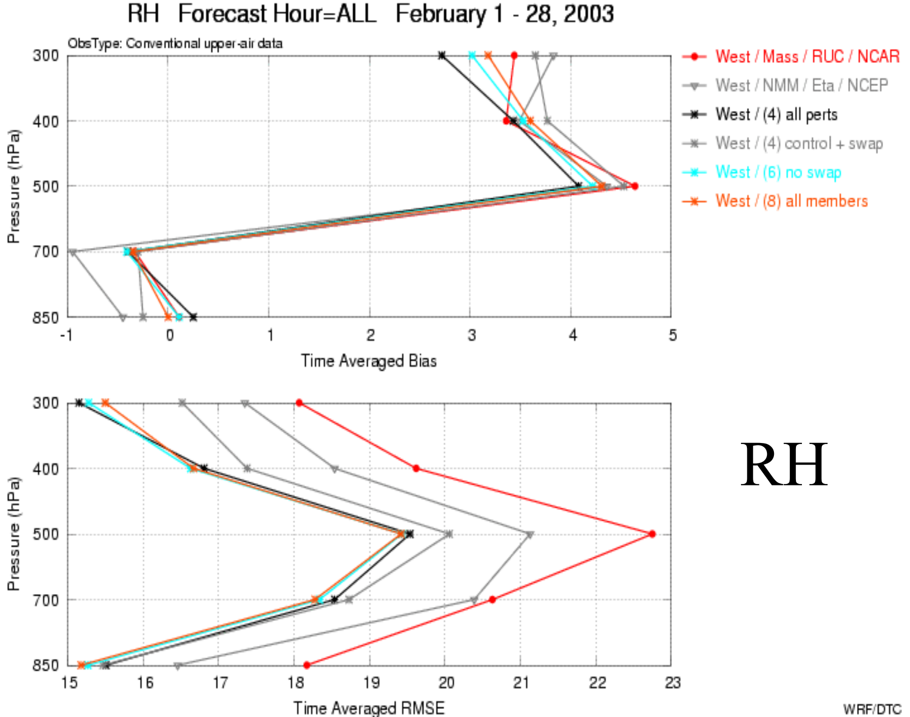
Vector Wind Forecast Hour=ALL February 1 - 28, 2003
ObsType: Conventional upper-air data
West / Mass / RUC / NCAR
West / NMM / Eta / NCEP
West / (4) all perts
West / (4) control + swap
West / (6) no swap
West / (8) all members
Pressure (hPa)
Time Averaged Bias
Time Averaged RMSE
WRF/DTC

Wind



Height (Z) Forecast Hour=ALL February 1 - 28, 2003
ObsType: Conventional upper-air data
West / Mass / RUC / NCAR
West / NMM / Eta / NCEP
West / (4) all perts
West / (4) control + swap
West / (6) no swap
West / (8) all members
Pressure (hPa)
Time Averaged Bias
Time Averaged RMSE
WRF/DTC

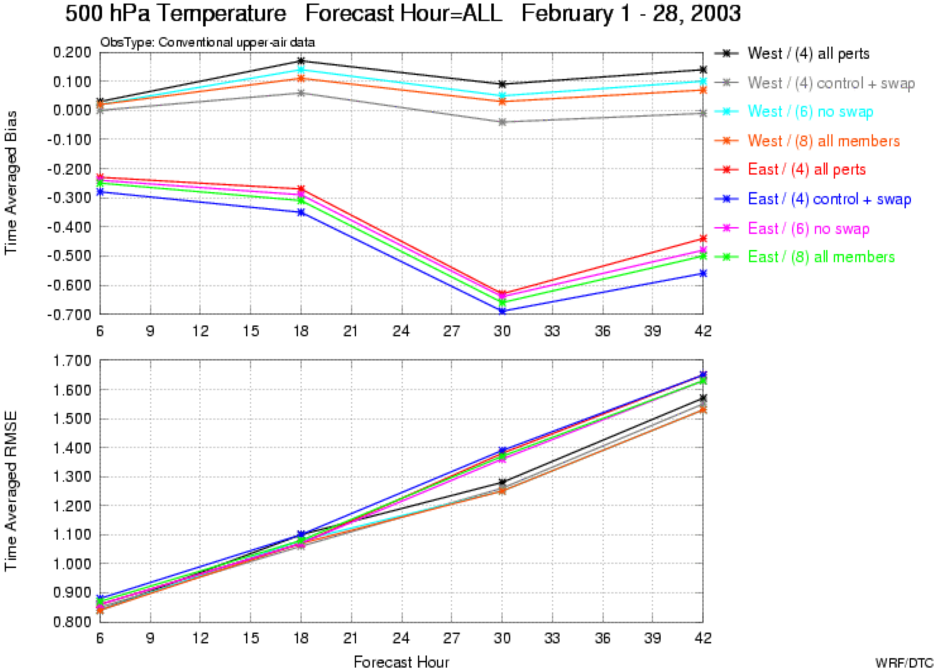
Z



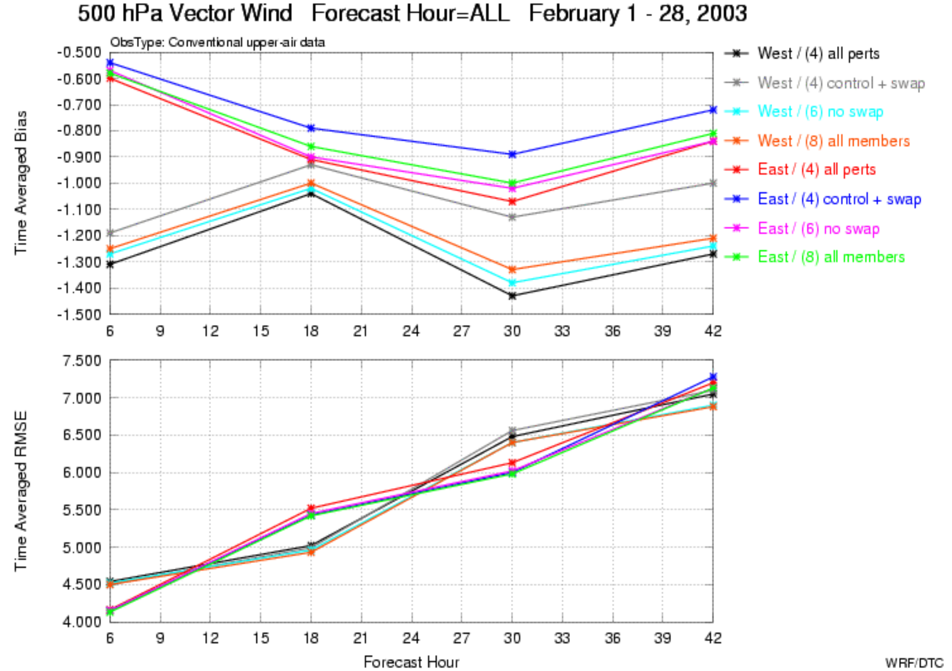
RH Forecast Hour=ALL February 1 - 28, 2003
ObsType: Conventional upper-air data
West / Mass / RUC / NCAR
West / NMM / Eta / NCEP
West / (4) all perts
West / (4) control + swap
West / (6) no swap
West / (8) all members
Pressure (hPa)
Time Averaged Bias
Time Averaged RMSE
WRF/DTC

RH

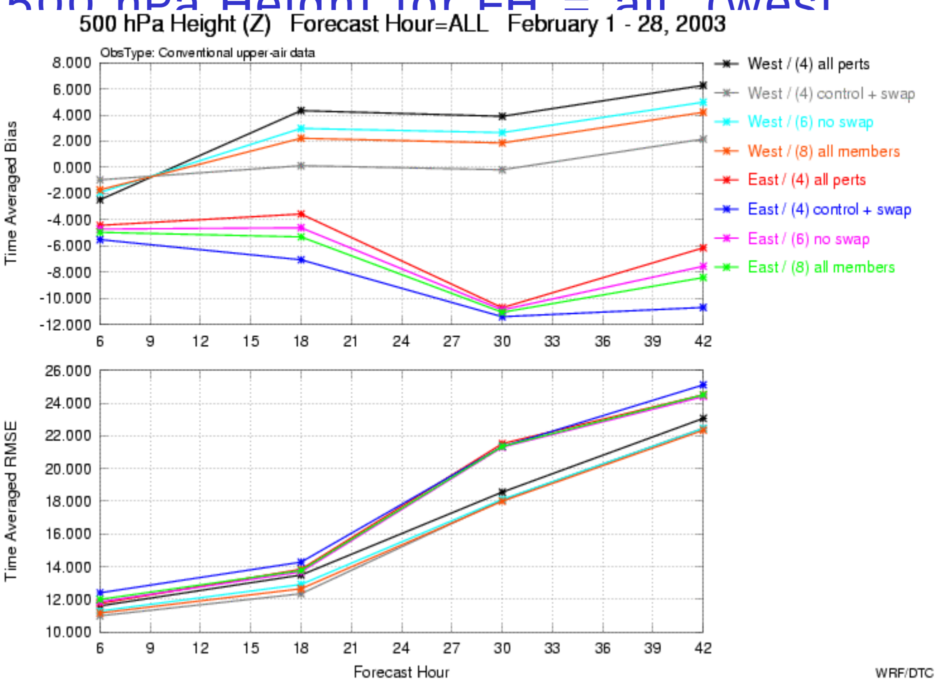
500 hPa Temperature for FH = all



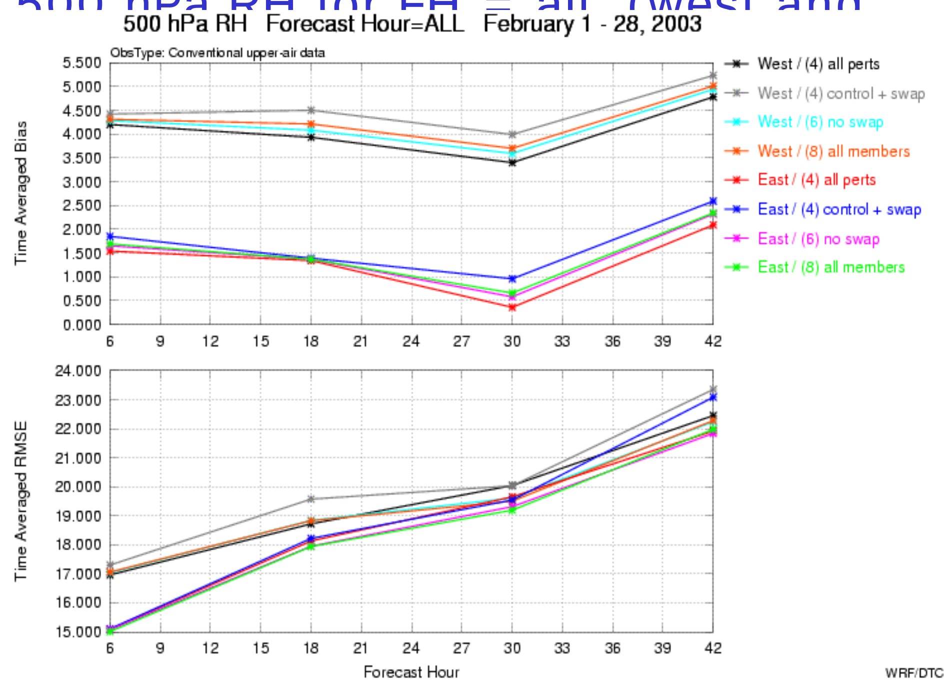
500 hPa Vector Wind for FH = all



500 hPa Height for FH = all (west



500 hPa RH for FH = all (west and



Ensemble Verification

Based on verification vs radiosonde obs

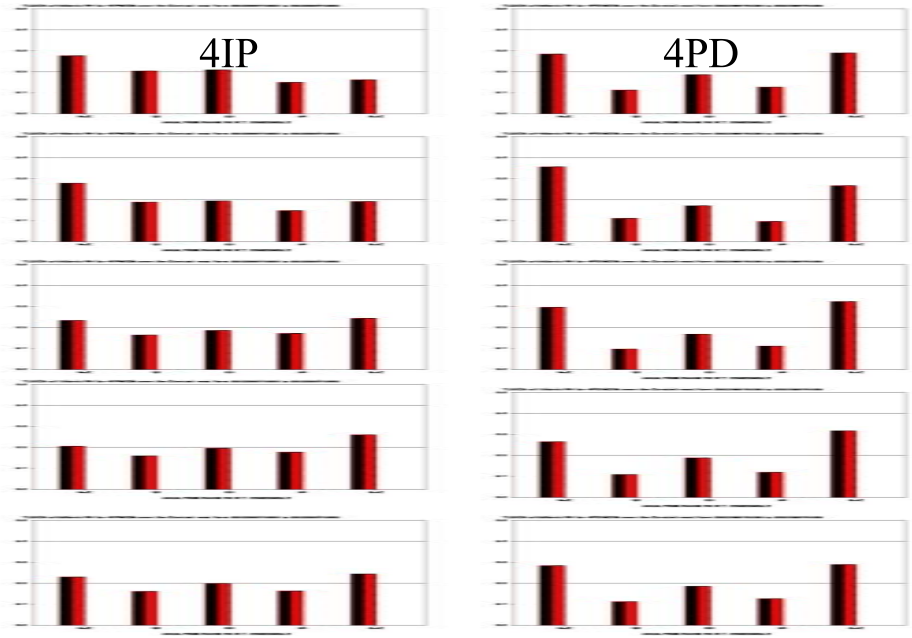
4 Initial Perturbation (IP) vs 4 Physics Diversity (PD)

IP More Uniform Ranked Histograms

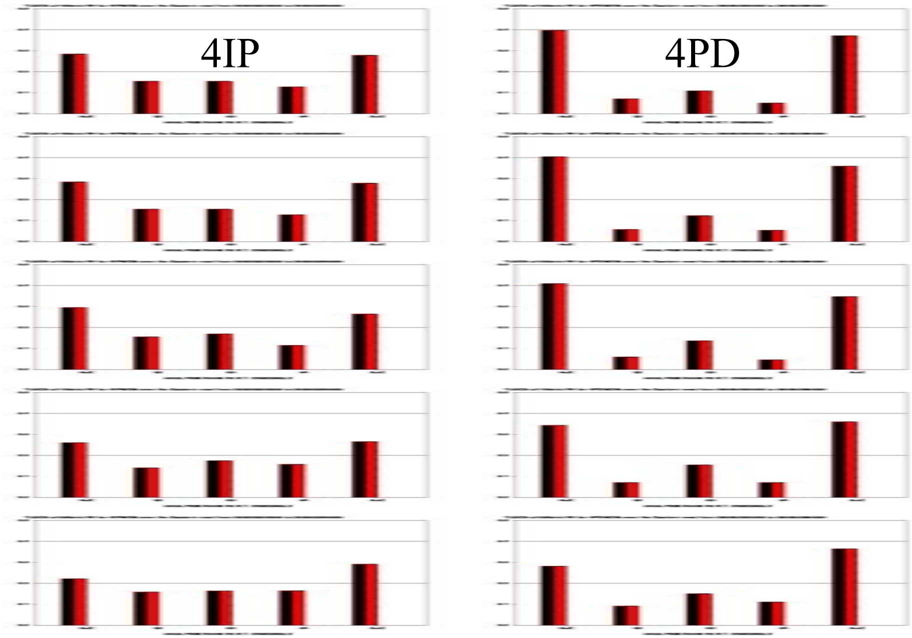
Legend for Subsequent Summaries
All Forecast Ranges Combined

300 mb	300 mb
400 mb	400 mb
500 mb	500 mb
700 mb	700 mb
850 mb	850 mb

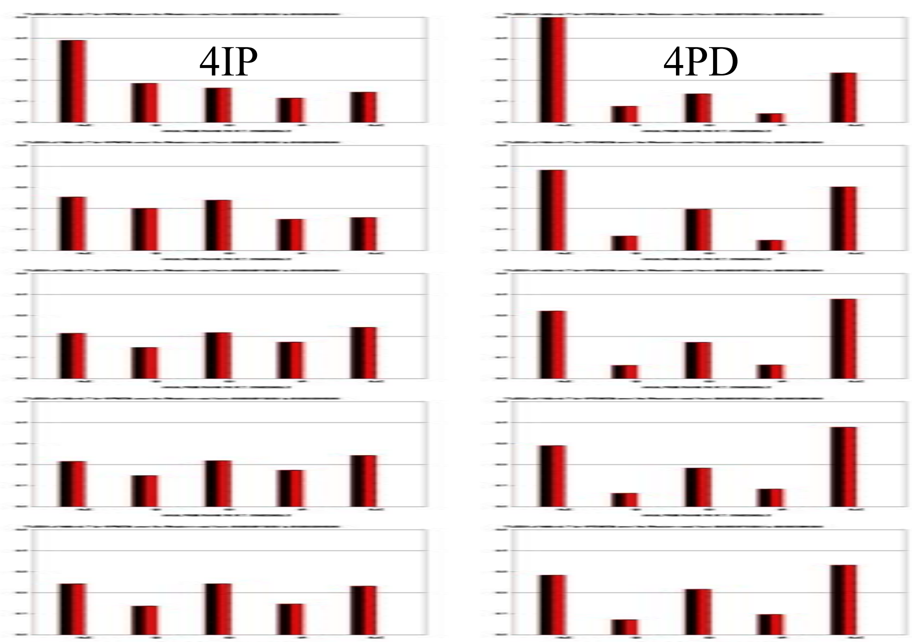
Equally Likely Central Summer RH



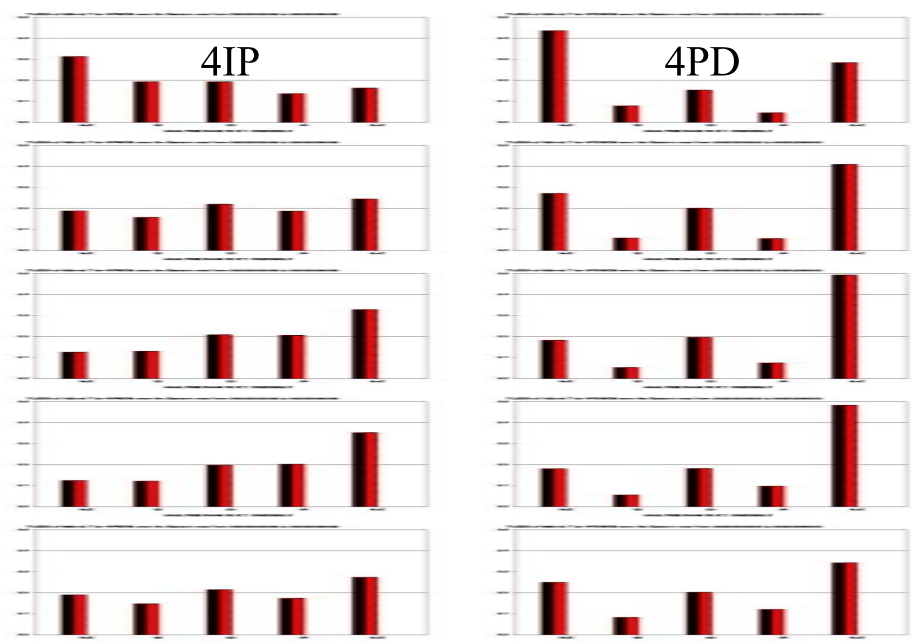
Equally Likely Eastern Winter RH



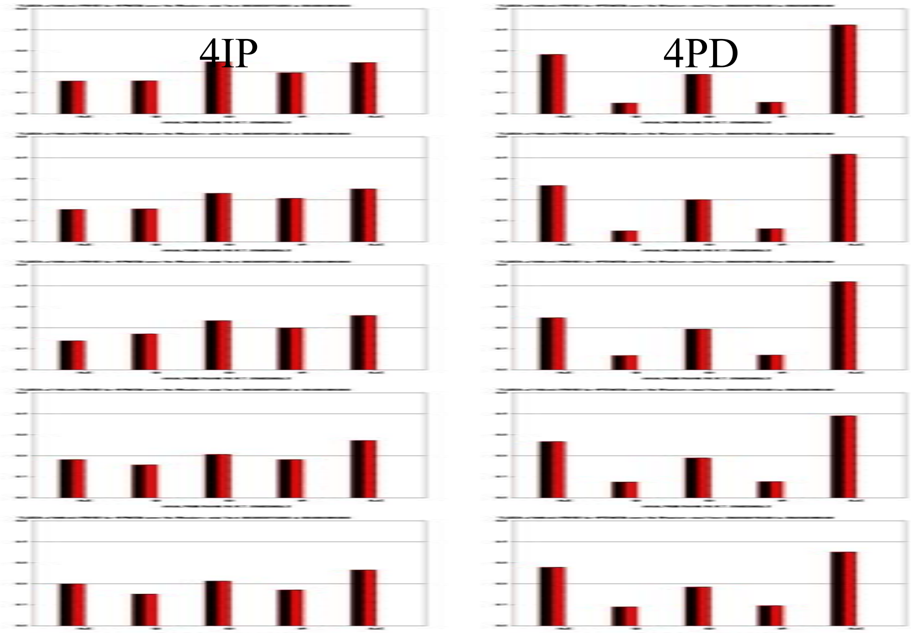
Equally Likely Western Winter Temp



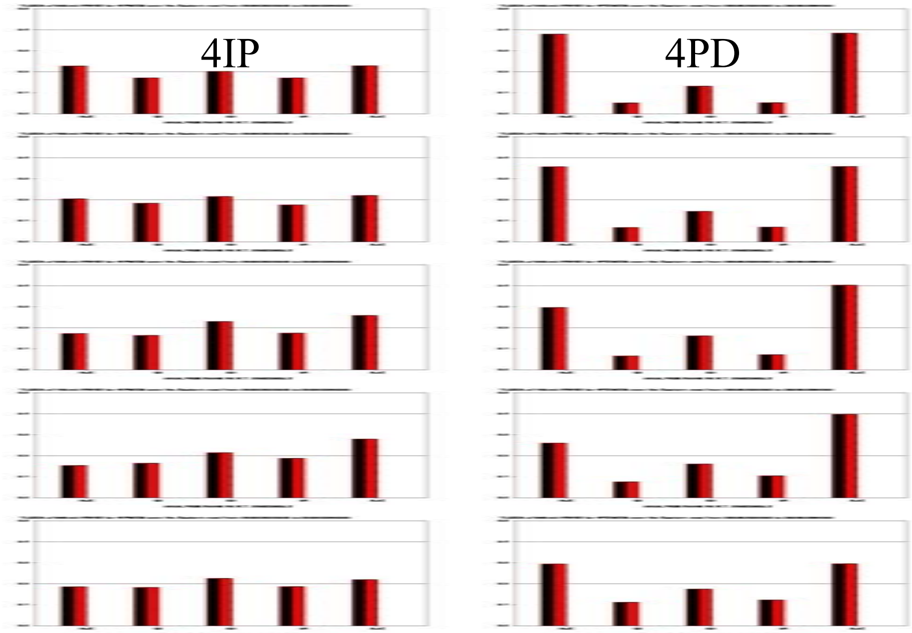
Equally Likely Eastern Winter Temp



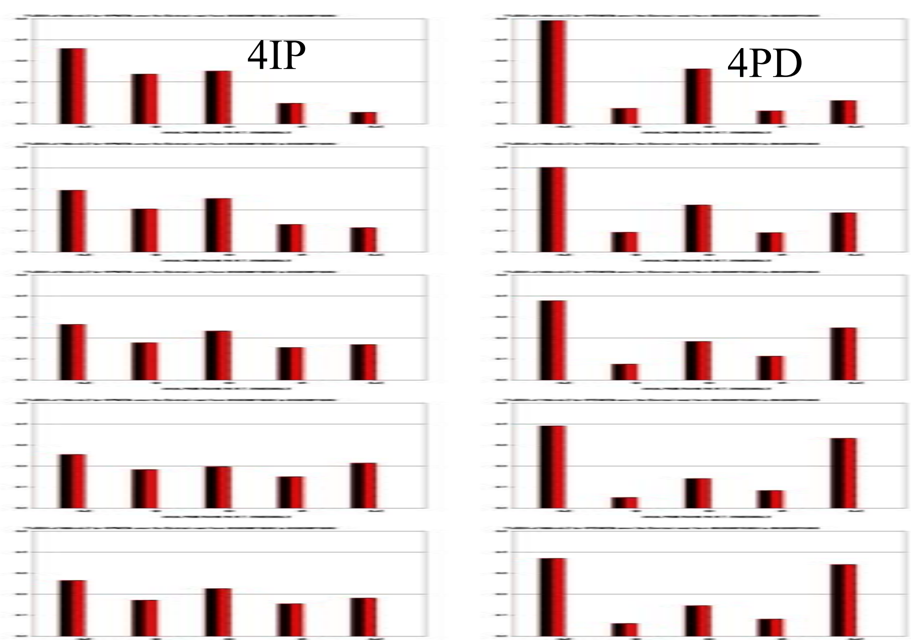
Equally Likely Western Winter Wind



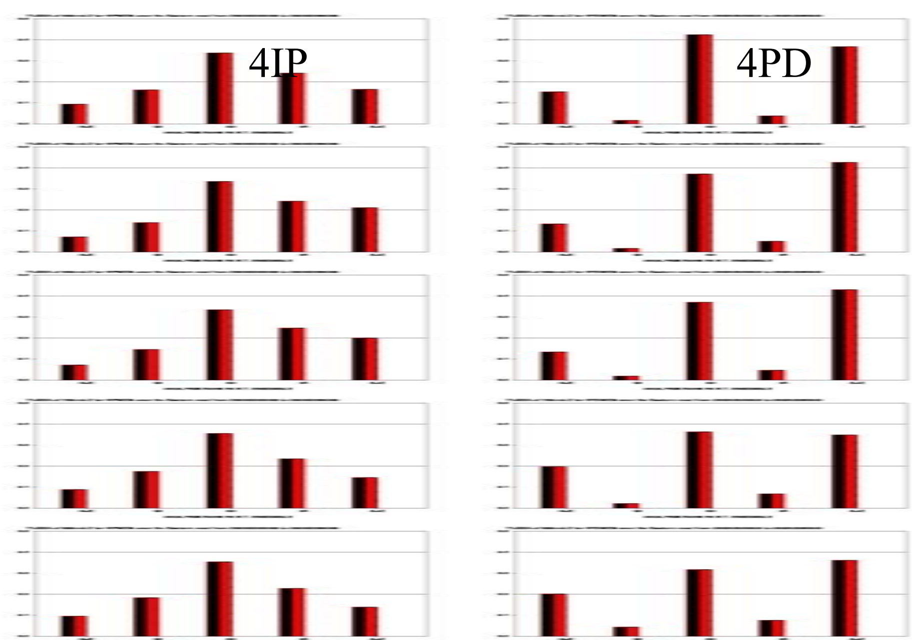
Equally Likely Eastern Winter Wind



Equally Likely Central Summer Height



Equally Likely Eastern Winter Height

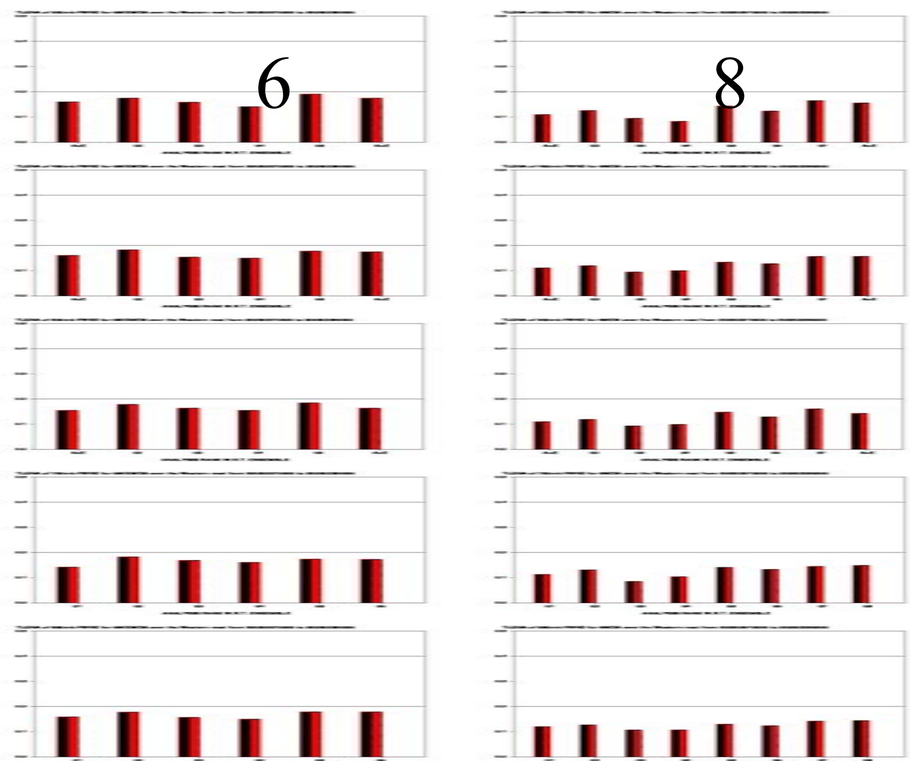


CHOICE OF SIX MEMBERS

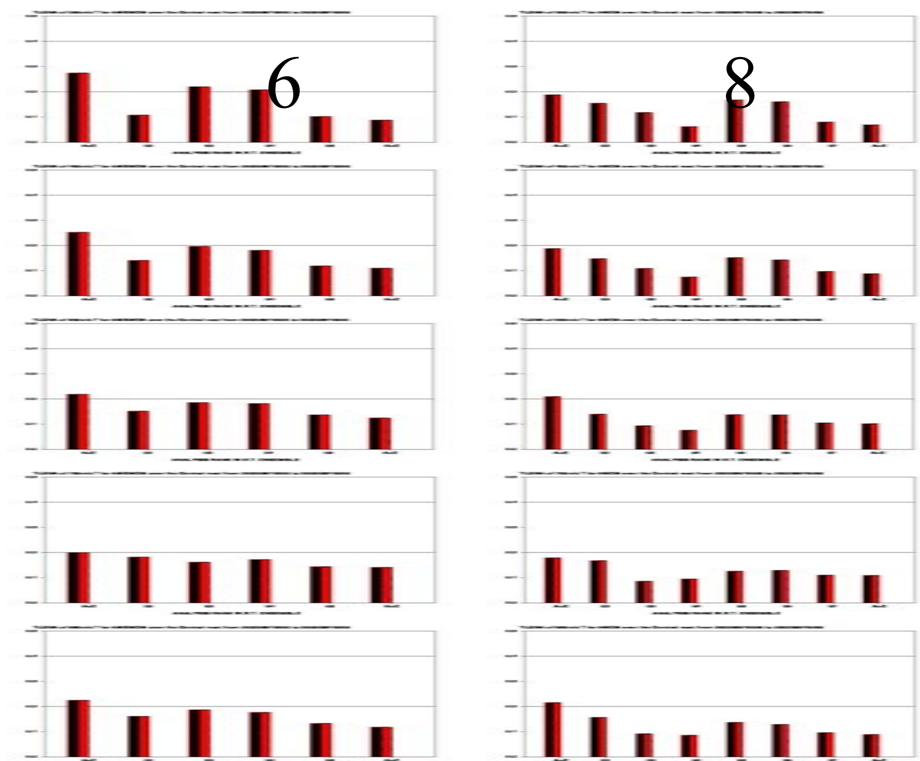
2 Controls + 2 IP-Breeding Pairs

This 6 Member Ensemble Is Almost As Good As The Complete 8 Member Ensemble

Nearest Truth Western Winter Wind



Nearest Truth Central Summer Temp



WRF System Description – HRW Implementation

Description: The WRF modeling system consists of…

Component	Source	Code History
• Two dynamical cores	NCEP & NCAR	new
• Two complete physics suites	NCEP & NCAR	modified MM5 & Eta
• Preprocessing for ICs/BCs	FSL & NCEP	new
• Post-processing for product generation	NCEP	modified Eta
• Statistical evaluation package	NCEP	modified Eta
• Software engineering infrastructure	NCAR	new
• Ensembling software	NCEP	new

Implementation Strategy – Phase 1

- **Phase 1— Implement new model (Threshold):** **IOC (21 September 2004)**

  - **Two deterministic "control" versions** of WRF will run four times daily, once for each of four large windows (twice for small windows).

    - NCAR EM core: 10-km horizontal resolution, 50 layers
    - NCEP NMM core: 8-km horizontal resolution, 60 layers

  - **80-min run window (clock time) shared** with GFDL Hurricane model
  - **Availability contingent** on tropical weather situation.
    - If 1 tropical storm present, WRF runs for HI & PR will be dropped out.
    - If 2 tropical storms present, WRF-EM run will be dropped.
    - If 3 or more tropical storms present, both WRF runs will be dropped.

Implementation Strategy – Phase 2

- **Phase 2— Implement 6 member WRF ensemble** **target Feb/March 2005**

  - **Two "control" versions & two breeding cycle pairs** will run four times daily, once for each of four large windows (twice for small windows).

    - NCAR EM core: 10-km horizontal resolution, 50 layers
      Positive bred mode plus Negative bred mode
    - NCEP NMM core: 8-km horizontal resolution, 60 layers
      Positive bred mode plus Negative bred mode

  - **80-min run window (clock time) shared** with GFDL Hurricane model but with increased computer power with CCS upgrade complete
  - **Availability** still **contingent** on tropical weather situation.
    - If 1/2 tropical storm present, WRF-EM bred mode runs will be dropped.
    - If 3/4 tropical storms present, WRF-NMM bred mode runs will be dropped.

- Two control versions ALWAYS run

Review of Operational Readiness:

1. Objective Verification

Key:

Compared to the operational NMM, WRF has…

- Significant positive impact:	++	(2)
- Small positive impact:	+	(1)
- About neutral impact:	⟷	(0)
- Small negative impact:	-	(-1)
- Significant negative impact:	--	(-2)

Good to Go	**Area has Some Risk**	**Remedial Action Required**

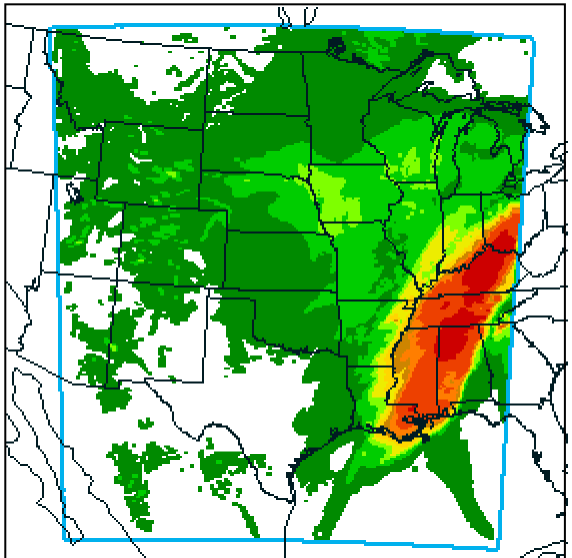
Review of Operational Readiness:

1. Objective Verification

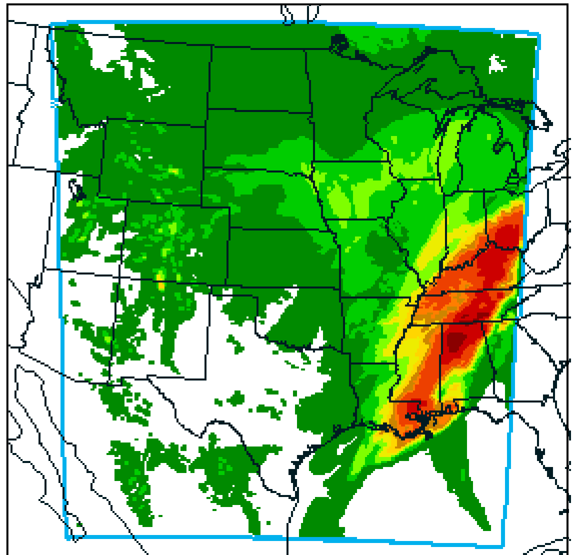
Variable	Season	West HRW Domain		East HRW Domain		NET
Wind profile	Jan-Mar 04	Bias: ++	RMSE: -	Bias: ++	RMSE: ↔	3
Height profile	Jan-Mar 04	Bias: --	RMSE: ↔	Bias: ++	RMSE:++	2
Temp. profile	May-Aug 04	Bias: -	RMSE: -	Bias: -	RMSE: -	-4
Rel. Hum. profile	May-Aug 04	Bias: ↔	RMSE: ↔	Bias: +	RMSE ↔	1
10-m Winds	Jan-Mar 04	Bias: ++	RMSE: +	Bias: +	RMSE: -	3
2-m Temp.	All	Jan-Aug ↔ Fcst-Obs.	May-Aug:+ Fcst-Obs.	Jan-Aug+ Fcst-Obs.	May-Aug+ Fcst-Obs.	3
Large Scale* Precipitation	Jan-Mar 04	ETS: -	Bias: --	ETS: ↔	Bias: +	-2
Large Scale* Precipitation	May-Aug 04	ETS: ↔	Bias: --	ETS: +	Bias: --	-4

*No mature objective score for SMALL Scale Precipitation

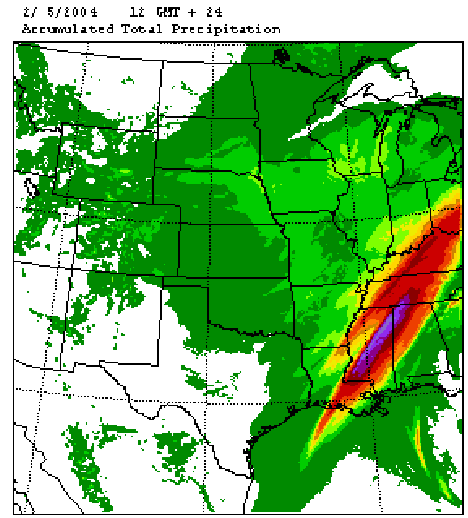
“WRF-NMM has more fine-scale precip structure than oper. NMM”



Operational NMM

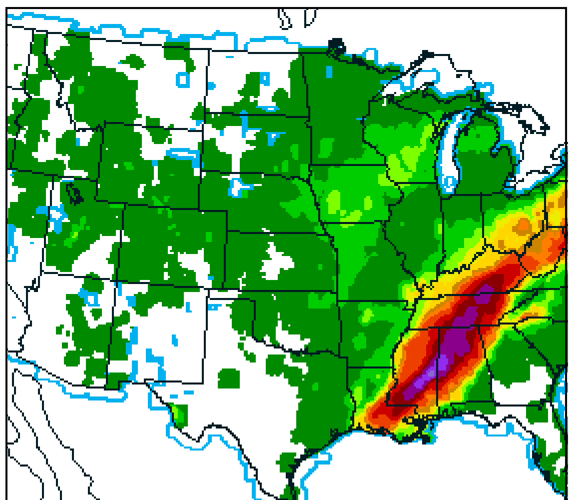


Early WRF-NMM



WRF-NMM with New BMJ Convection

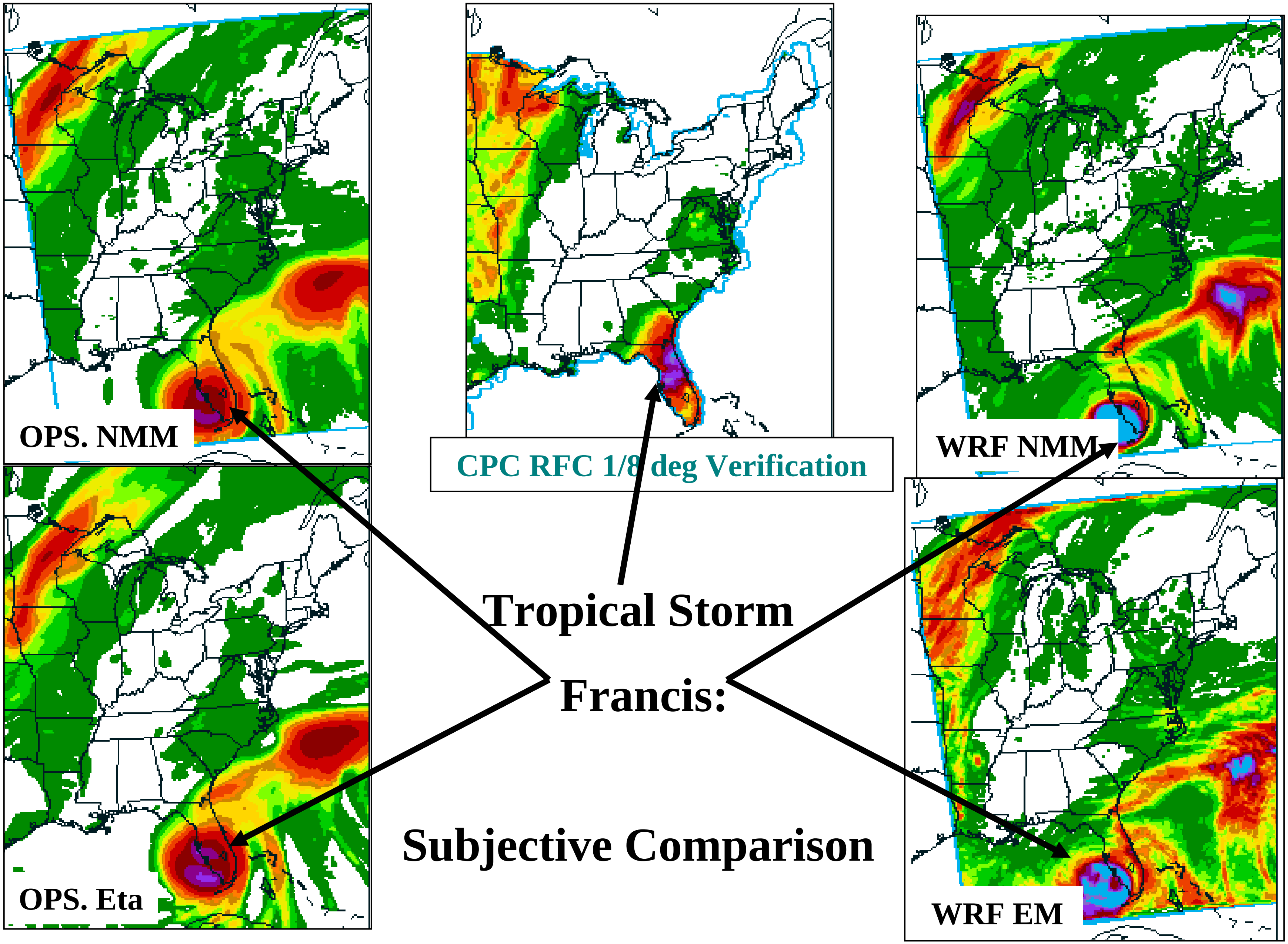
24 hour accumulations,
24-48 hours,
ending 12 Z February 6, 2004



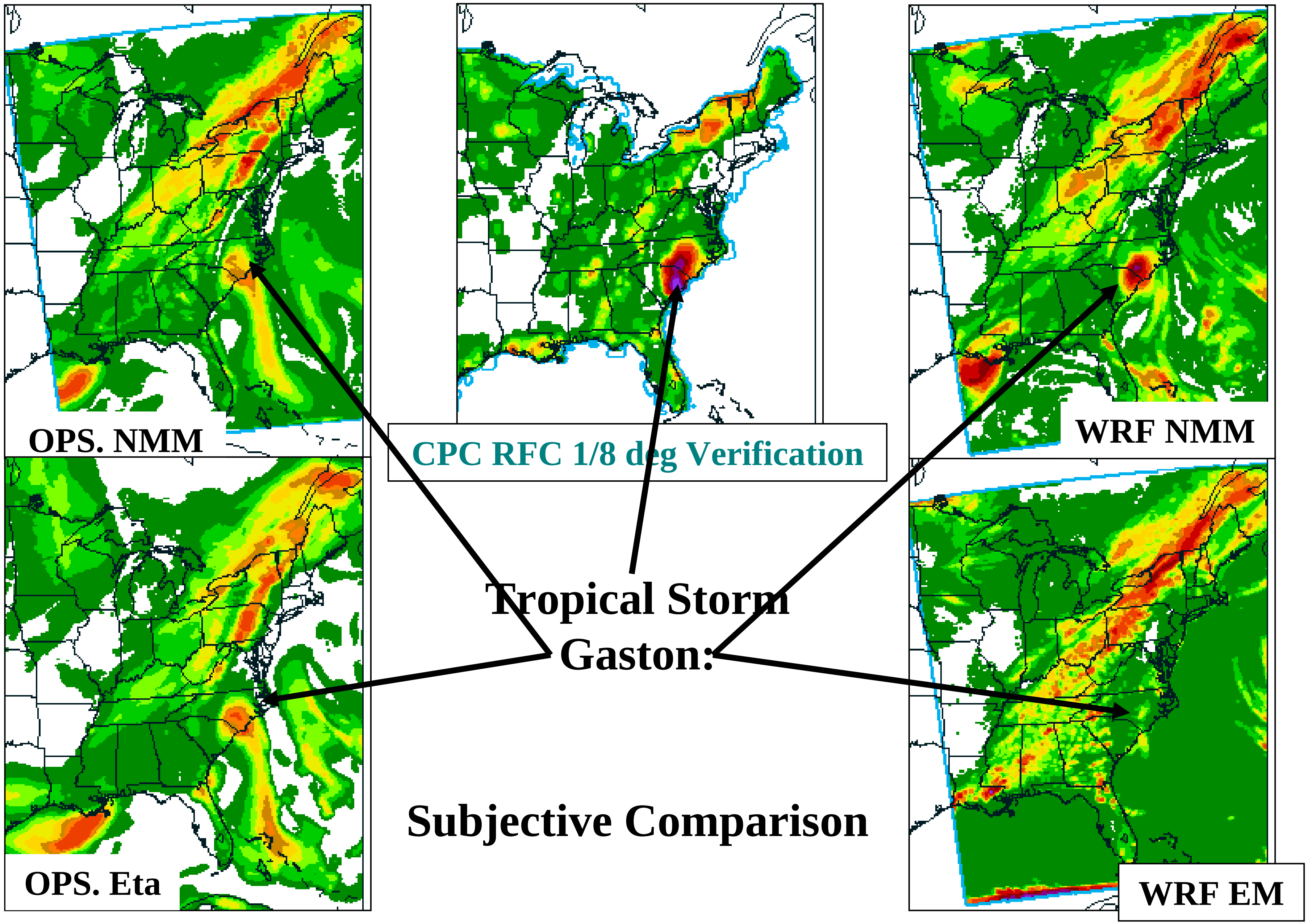
Verification

Implemented in Initial Operational Configuration

24 Hour Accumulated Precipitation Valid 12Z 6 September, 2004, 42 Hour Forecast



24 Hour Accumulated Precipitation Valid 12Z 30 August, 2004, 42 Hour Forecast



Air Quality Prediction at NCEP

Jeff McQueen, Pius Lee, Marina Tsildilko, with Geoff DiMego, Hui-Ya Chuang and Eric Rogers

CONGRESSIONAL EARMARK

Paula Davidson – NWS/HQ/OST Program Manager

Vision

National Air Quality Forecast System which provides the US with ozone, particulate matter and other pollutant forecasts with enough accuracy and advance notice to take action to prevent or reduce adverse effects

Strategy

Work with EPA, State and Local Air Quality agencies and private sector to develop end-to-end air quality forecast capability for the Nation

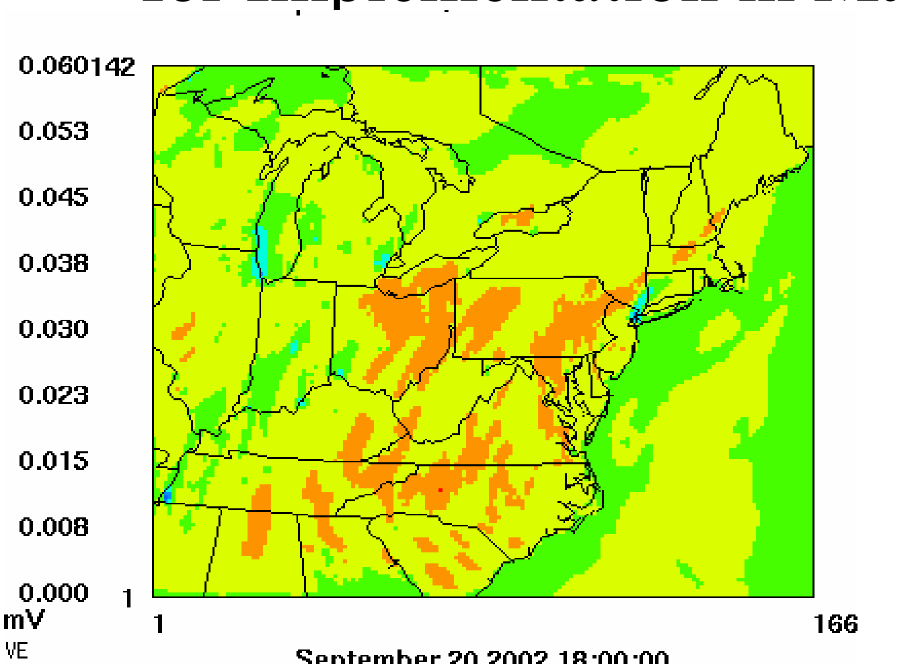
<u>National Air Quality Forecasting</u>

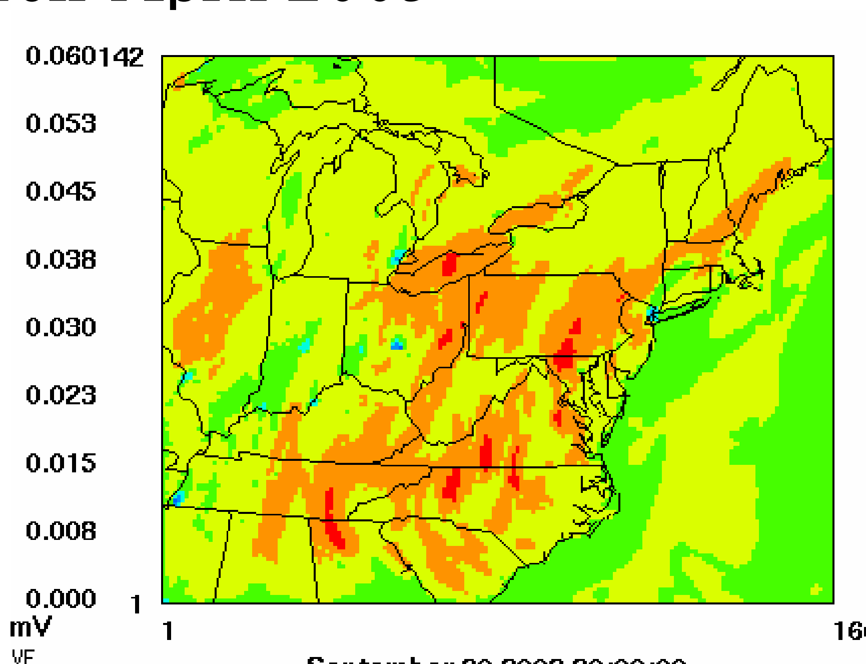
Planned Capabilities

- Initial (1-5 years started FY2003) :
  - 1-day forecasts of surface ozone (O_3) concentration
  - Develop and validate in Northeastern US in 2 years
  - Deploy Nationwide within 5 years
- Intermediate (5-7 years):
  - Develop and test capability to forecast particulate matter (PM) concentration
    - Particulate size $\leq$ 2.5 microns
- Longer range (within 10 years):
  - Extend air quality forecast range to 48-72 hours
  - Include broader range of significant pollutants
- <u>Program has purchased additional computer power</u> to perform AQF and promised this increment for perpetuity

AQFS Implementation

- IOC Northeastern US Domain NAM/Eta driving CMAQ 12 km grid spacing on 22 vertical sigma levels
- Development Test & Evaluation was run in 2003
- Operational Test & Evaluation was run in 2004
- AQFS Declared Operational 17 September 2004
- Eastern US upgraded AQFS DT&E in 2004 -- ready for Implementation in March-April 2005





NCEP Regional Reanalysis

http://wwwt.emc.ncep.noaa.gov/mmb/rreanl/index.html

Fedor Mesinger[1], Geoff DiMego[2], Eugenia Kalnay[3], Perry Shafran[4], Dusan Jovic[4], Wesley Ebisuzaki[5], Jack Woollen[4], Yun Fan[6], Robert Grumbine[2], Wayne Higgins[5], Hong Li[3], Ying Lin[2], Kenneth Mitchell[2], David Parrish[2], Eric Rogers[2], Wei Shi[6], and Diane Stokes[2]

[1]NCEP/EMC and UCAR, [2]NCEP/EMC, [3]Univ. of MD, [4]NCEP/EMC and SAIC/GSO, [5]NCEP/CPC, [6]NCEP/CPC and RSIS

Motivation for Regional Reanalysis

- Create long-term set of consistent climate data on a regional scale on North American domain
- Superior to NCEP/NCAR Global Reanalysis (GR) due to:
  - use of higher resolution regional model (the Eta model)
  - Advances in modeling and data assimilation since 1995, especially:
    - Precipitation assimilation
    - Direct assimilation of radiances
    - Land-surface model updates

http://wwwt.emc.ncep.noaa.gov/mmb/rreanl/index.html

NARR DATA AVAILABLE AT NCDC! ALL YEARS 1979-2003!! Click here to download data.

Click here for latest updates of presentations and documents.

NARR Climatologies

North American Regional Reanalysis climatologies are now available, courtesy of the Climate Prediction Center. For more information regarding the climatologies, click one of the following:

- Information on the climatologies, MS Word format
- Climatology summary, MS Power Point format
- Information on the climatologies, text format
- List of variables in climatologies, MS Excel format

The climatologies are archived on UCAR's JOSS (Joint Office for Science Support) system. Three climatologies are available:

- 3 hourly climatologies
- Daily climatologies
- Monthly mean climatologies

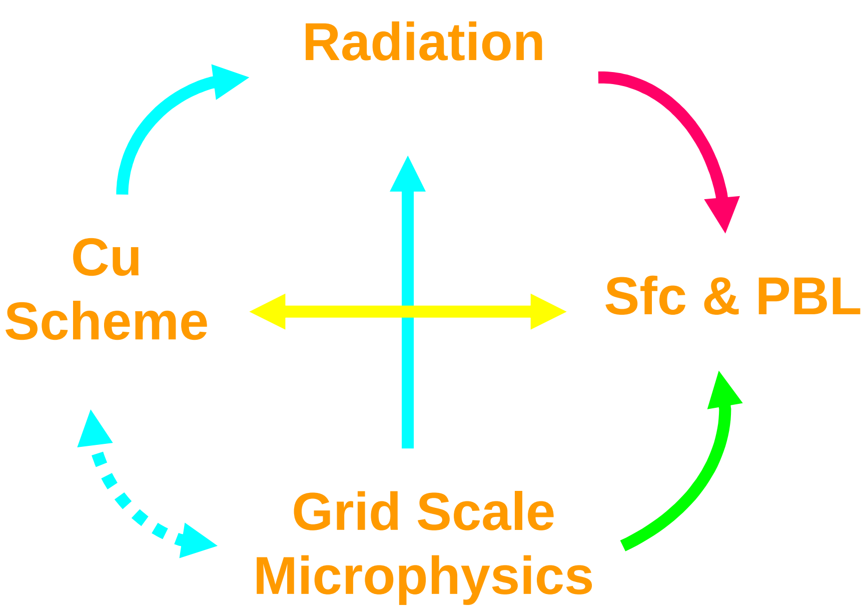
Contents of Final NAM/Eta (&DGEX) Bundle Expected by Spring 2005

- 3DVAR analysis changes
  - Assimilate Level 2.5 88D radial wind – superobs generated onsite
  - Add 2D-VAR analysis of surface land temperature observations
- Precip Assimilation change
  - Drive surface energy balance directly with observed precipitation
  - Stop aggressive attempts to add latent heat/moisture to create precip
- Eta model - Radiation and Cloud Changes
  - Lower limit on optical depth for stable liquid water clouds is being removed with large effect
  - Water & ice absorption coefficients in Lacis-Hansen shortwave scheme modified to be more consistent with those in the GFS radiation scheme
  - Calculations of optical depths (used for calculating absorption) are made to be consistent with those used in Hou et al. (2002) for GFS
- Eta model – Land-surface model upgrades

"THE PHYSICS WHEEL OF PAIN"

Direct Physical Interaction of Clouds

Compliments of Dr. Jaiyu Zhou (NOAA/OST)



1. - Hydrometeor type (phase)
   - Cloud optical properties
   - Cloud overlap (merging Cu, grid-scale cloudiness)
   - Cloud fractions
2. - Precipitation
3. - Sfc energy fluxes
4. - Convection, PBL evolution, precipitation

http://wwwt.emc.ncep.noaa.gov/mmb/mmbpll/paralog/paralog.etax.winter2005.html

Noah LSM Changes: Version 2.7 versus Ops Eta 2.3.2

1 – Reduce cool season daytime cool bias, especially over snow

- remove vegetation effect in snow albedo formulation
- refine patchy snow cover parameters
- when fractional snow cover present, separate the calculation of surface evaporation over snow-covered and non-snow covered patches

2 – Reduce warm season daytime warm bias

- reduce vegetation-dependent soil moisture threshold
- decrease thermal-roughness length coefficient (CZIL)
- diurnal surface albedo function of solar zenith angle

3 – Reduce nighttime cool bias

- increase ground heat flux at night by
  - -- increase thermal heat capacity of soil medium
  - -- increase depth of lower boundary condition on soil temperature

4 – Improve snowfall (precip-type) diagnosis in land-sfc physics

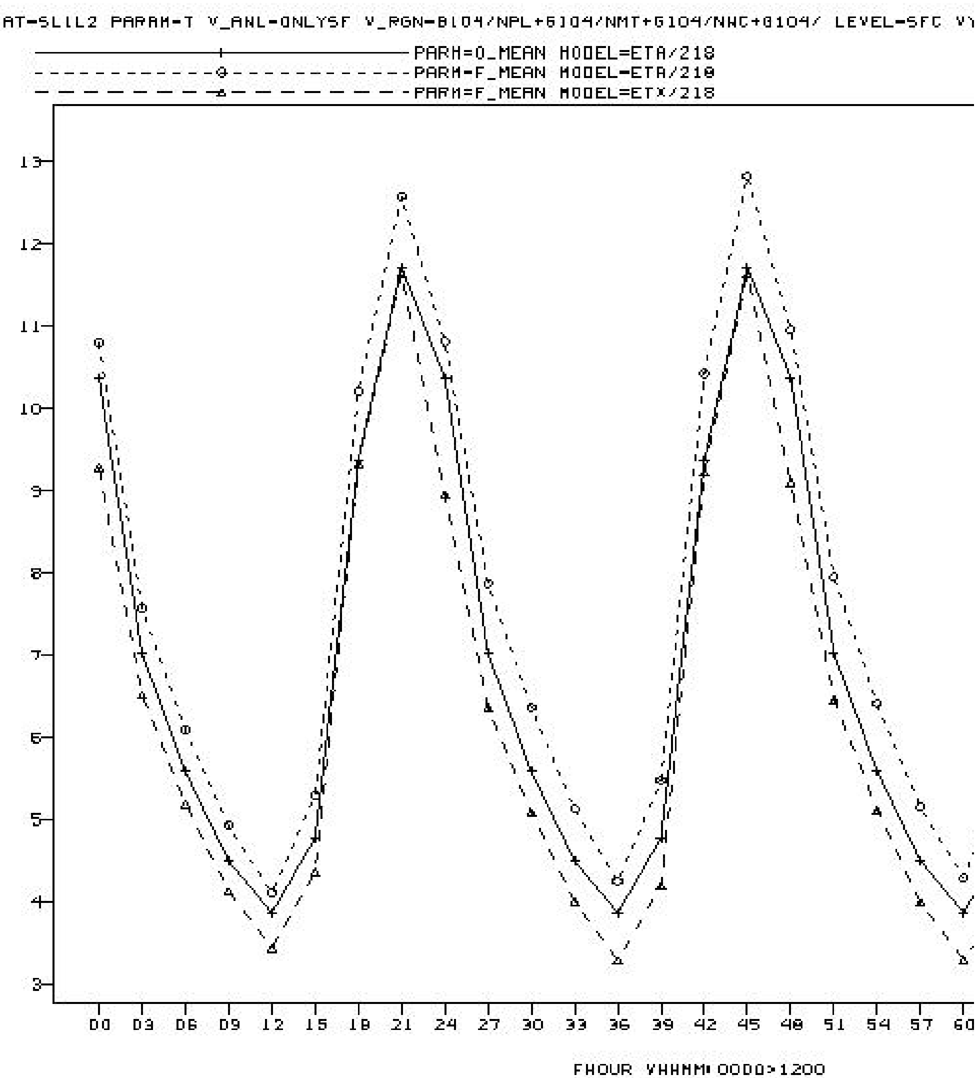
- pass fraction of frozen precip from Eta microphysics to land-sfc module

5 -- Miscellaneous

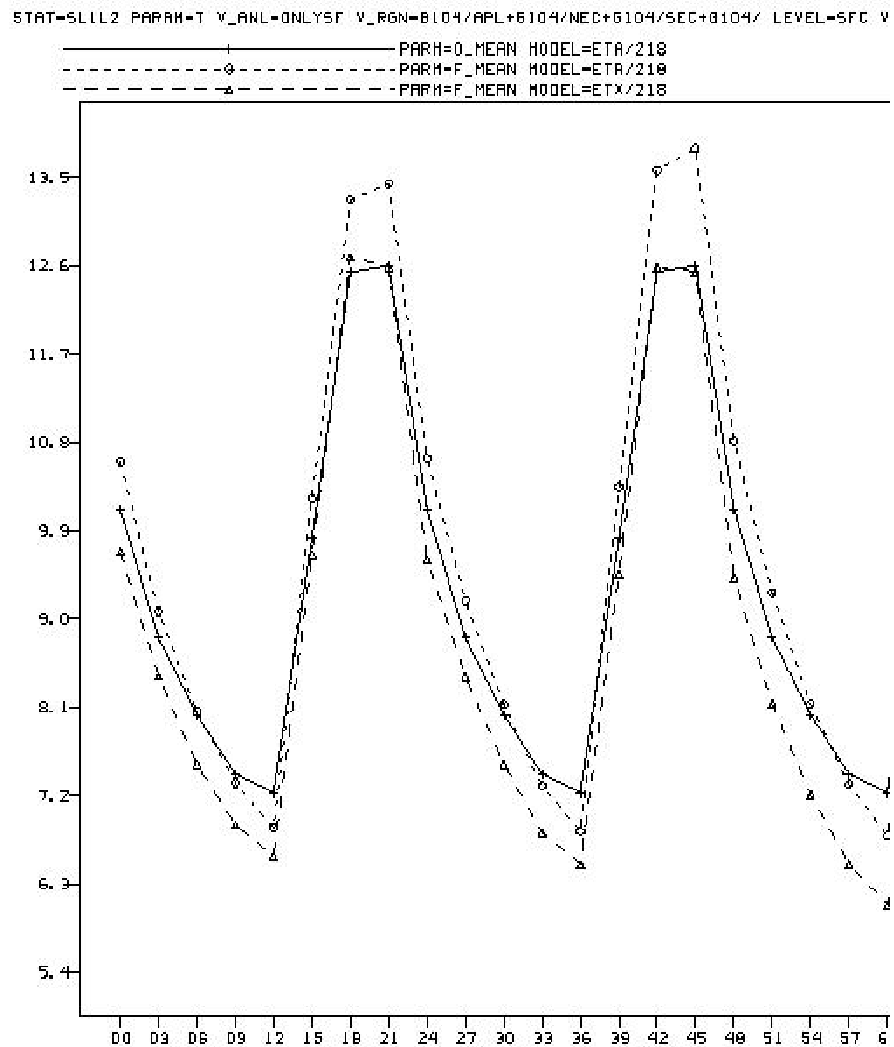
- move soil heat flux calculation to end of SFLX
- small bug fix to calculation of thermal diffusivity of the soil medium
- increase sea-ice albedo from 0.60 to 0.65.

2-m T

West



East



NOAH LSM Version 2.8

<u>SOIL</u> TYPE CLASS

1. SAND
2. LOAMY SAND
3. SANDY LOAM
4. SILT LOAM
5. SILT
6. LOAM
7. SANDY CLAY LOAM
8. SILTY CLAY LOAM
9. CLAY LOAM
10. SANDY CLAY
11. SILTY CLAY
12. CLAY
13. ORGANIC MATERIAL
14. WATER
15. BEDROCK
16. OTHER(land-ice)
17. PLAYA
18. LAVA
19. WHITE SAND

<u>Vegetation</u> / Surface Type Class

1. Urban and Built-Up Land
2. Dryland Cropland and Pasture
3. Irrigated Cropland and Pasture
4. Mixed Dryland/Irrigated Cropland and Pasture
5. Cropland/Grassland Mosaic
6. Cropland/Woodland Mosaic
7. Grassland
8. Shrubland
9. Mixed Shrubland/Grassland
10. Savanna
11. Deciduous Broadleaf Forest
12. Deciduous Needleleaf Forest
13. Evergreen Broadleaf Forest
14. Evergreen Needleleaf Forest
15. Mixed Forest
16. Water Bodies
17. Herbaceous Wetland
18. Wooded Wetland
19. Barren or Sparsely Vegetated
20. Herbaceous Tundra
21. Wooded Tundra
22. Mixed Tundra
23. Bare Ground Tundra
24. Snow or Ice
25. Playa
26. Lava
27. White Sand

N
C
E
P

Brad Colman & John Horel & ISST Mesoscale Analysis Committee Meeting

Geoff DiMego
13 October 2004

where the nation's climate and weather services begin

Workshop Conclusions

- NCEP's Rolls Royce Concept
  - NDFD resolution
  - 4-D Data Assimilation System
- Too Costly – Target this solution for true AoR
- Real-Time Mesoscale Analysis
  - Accepted as Phase I solution
  - To produce timely analyses for WFO's
- FSL + NCEP to partner in producing RTMA
  - Hourly RUC analysis downscaled to 5 km (FSL)
  - 5 km 2D-VAR analysis using anisotropic covariances, mesonet obs and downscaled RUC as first-guess (NCEP)
- *Subject to Availability of Resources – people & cpu's*

NCEP Has Total Data Access

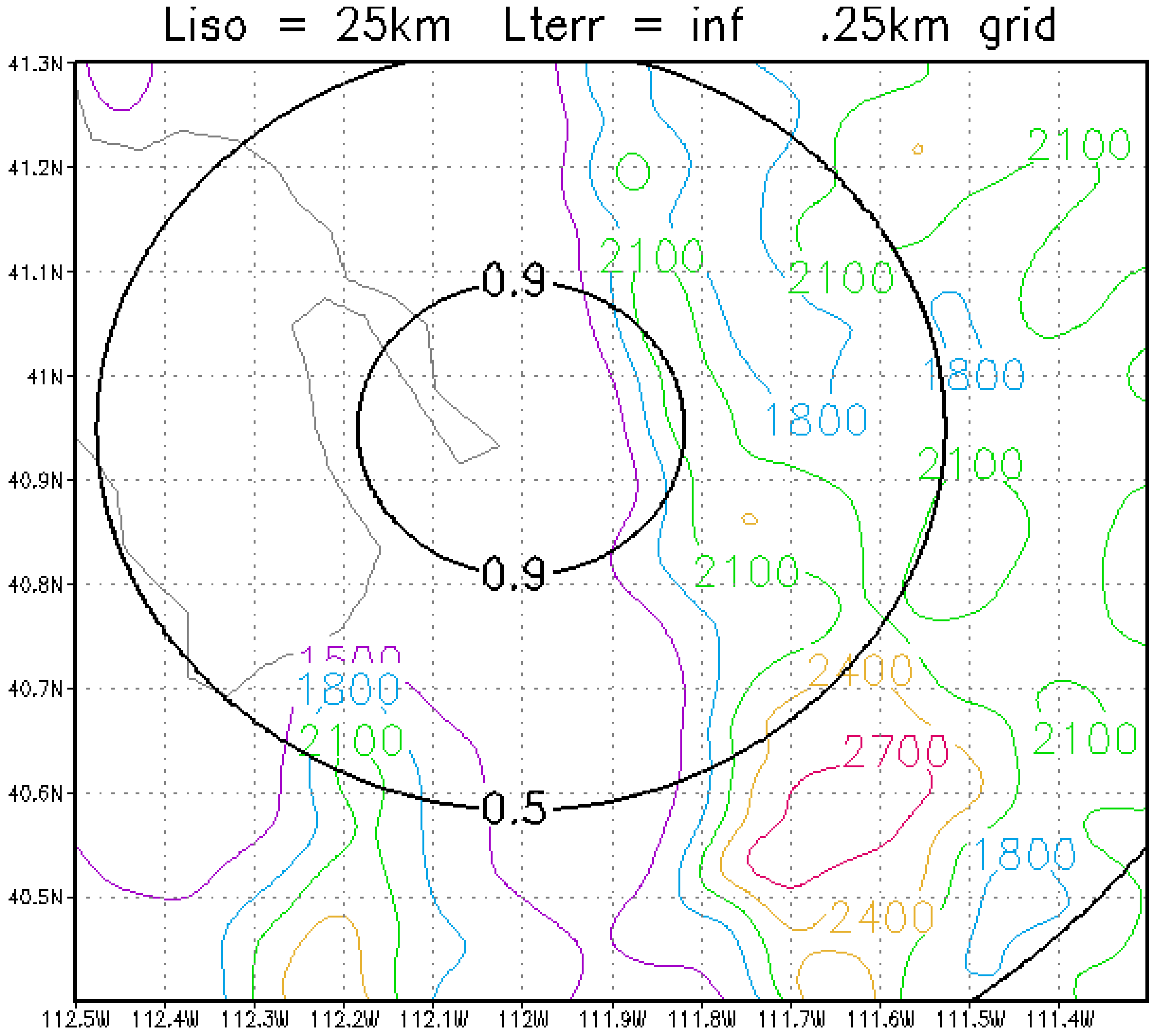
- Continuous data collection from all sources
  - Radiosondes, dropsondes, pibals, Profilers, RASS, VAD
  - Surface land (SYNOPs, METARs, mesonets)
  - Surface marine (ships, fixed & drifting buoys, CMANs, XBTs)
  - Aircraft (ACARS, AMDAR, AIREP, RECCO)
  - Satellite cloud-drift winds (visible, microwave, moisture)
  - Satellite radiances (DOD/NOAA/NASA polar + geostationary)
  - GPS IPW, SSM/I precip, scatterometer ocean sfc wind speed
  - Level II 88D radial velocity, reflectivity & spectrum width
- Anything available locally via LDAD can and should be sent to TOC in Silver Spring, MD and on to NCEP – this only takes seconds - most of these data are already getting to NCEP via FSL.

EMC Outreach and Leveraging

- EMC is partnering with Steve Lazarus and others who helped develop / adapt the ADAS to complex terrain at University of Utah
- Expect to partner with FSL on use of WRF-GSI in Rapid Refresh WRF application
- NCEP's 3DVAR / GSI is being adapted to use anisotropic covariance structures that follow the terrain, depend on atmospheric flow and stability.
- EMC leverages all the strengths of co-located Joint Center for Satellite Data Assimilation

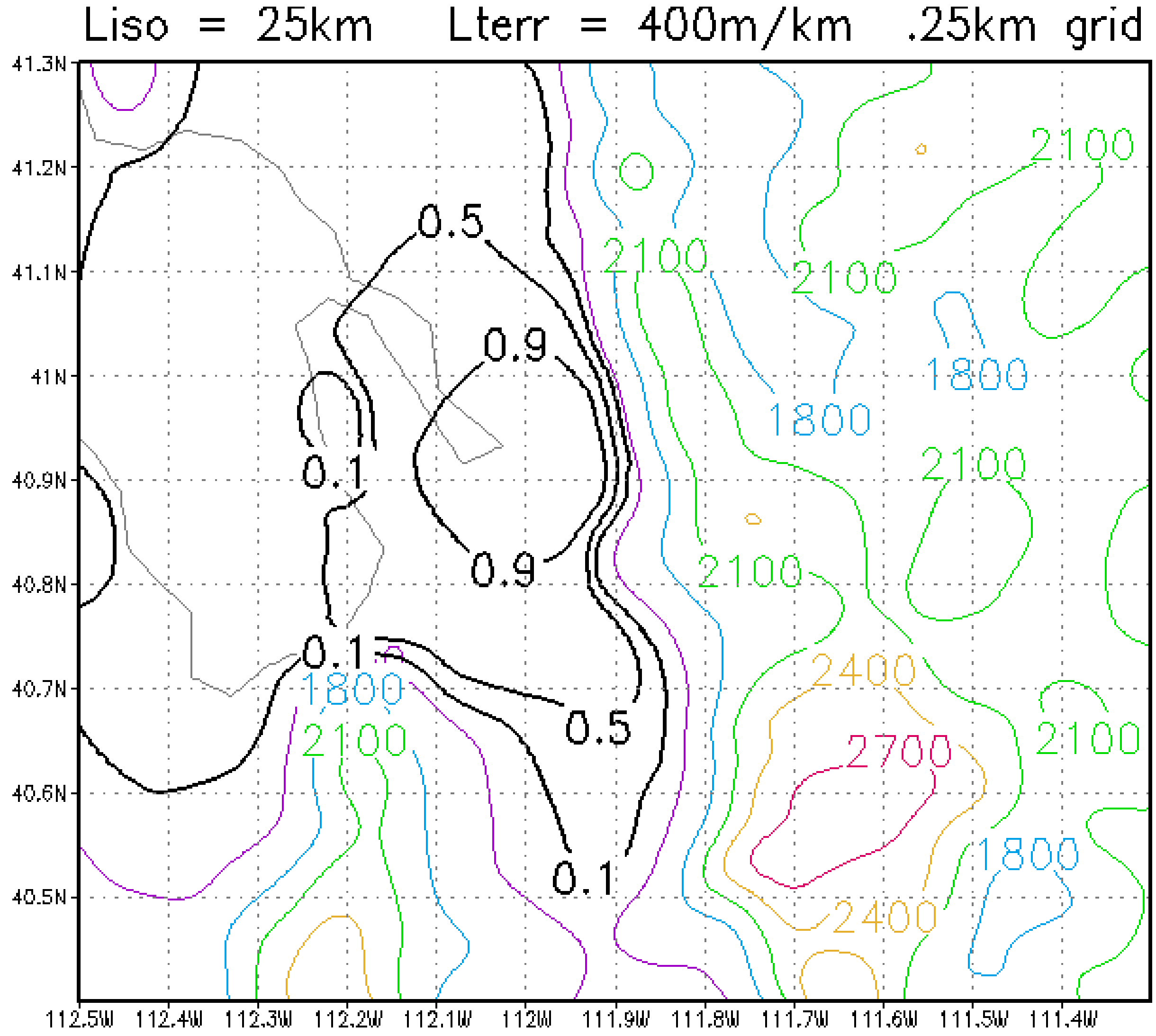
Isotropic Error Correlation in Valley Plotted Over Utah Topography

ob's influence extends into mountains indiscriminately



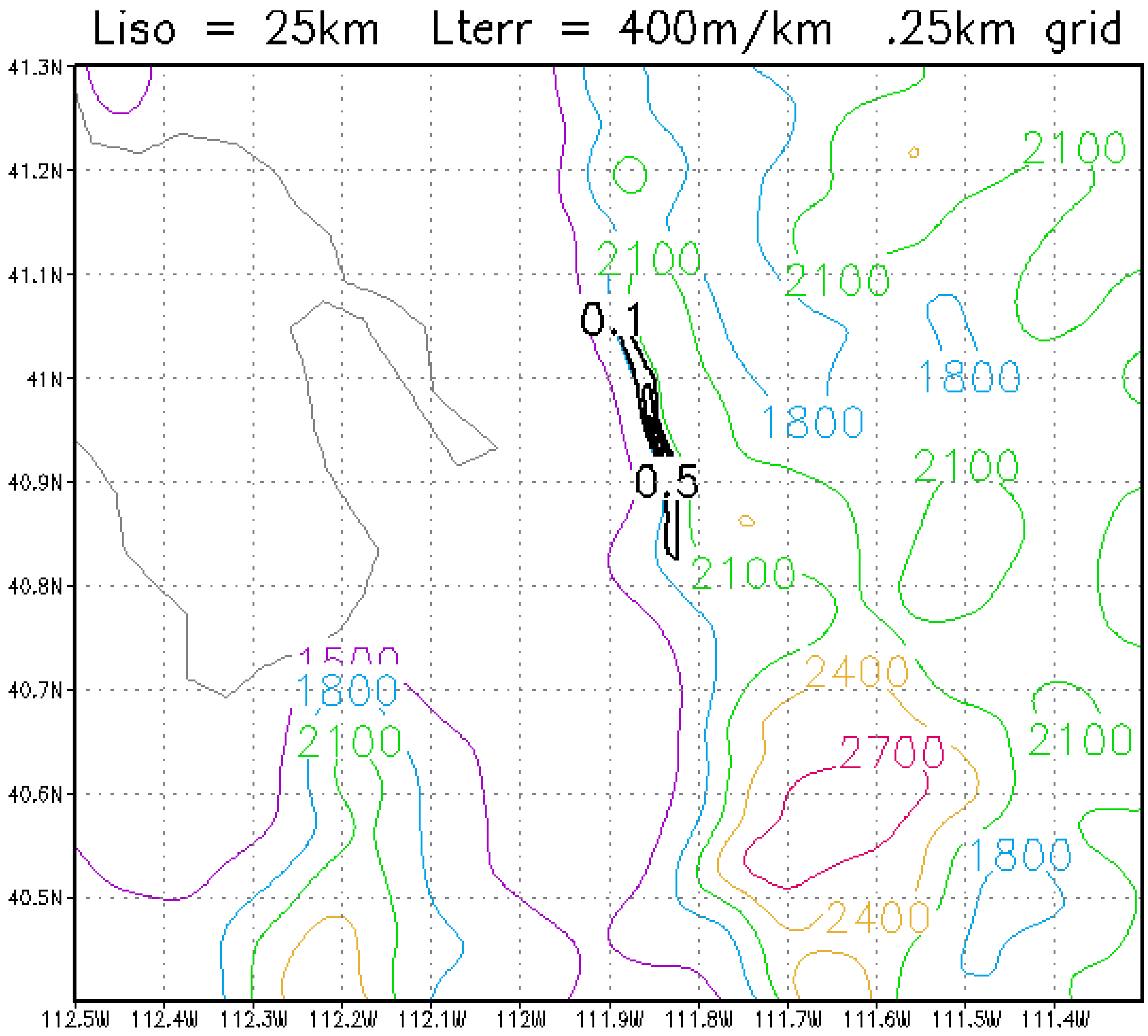
Anisotropic Error Correlation in Valley Plotted Over Utah Topography

ob's influence restricted to areas of similar elevation



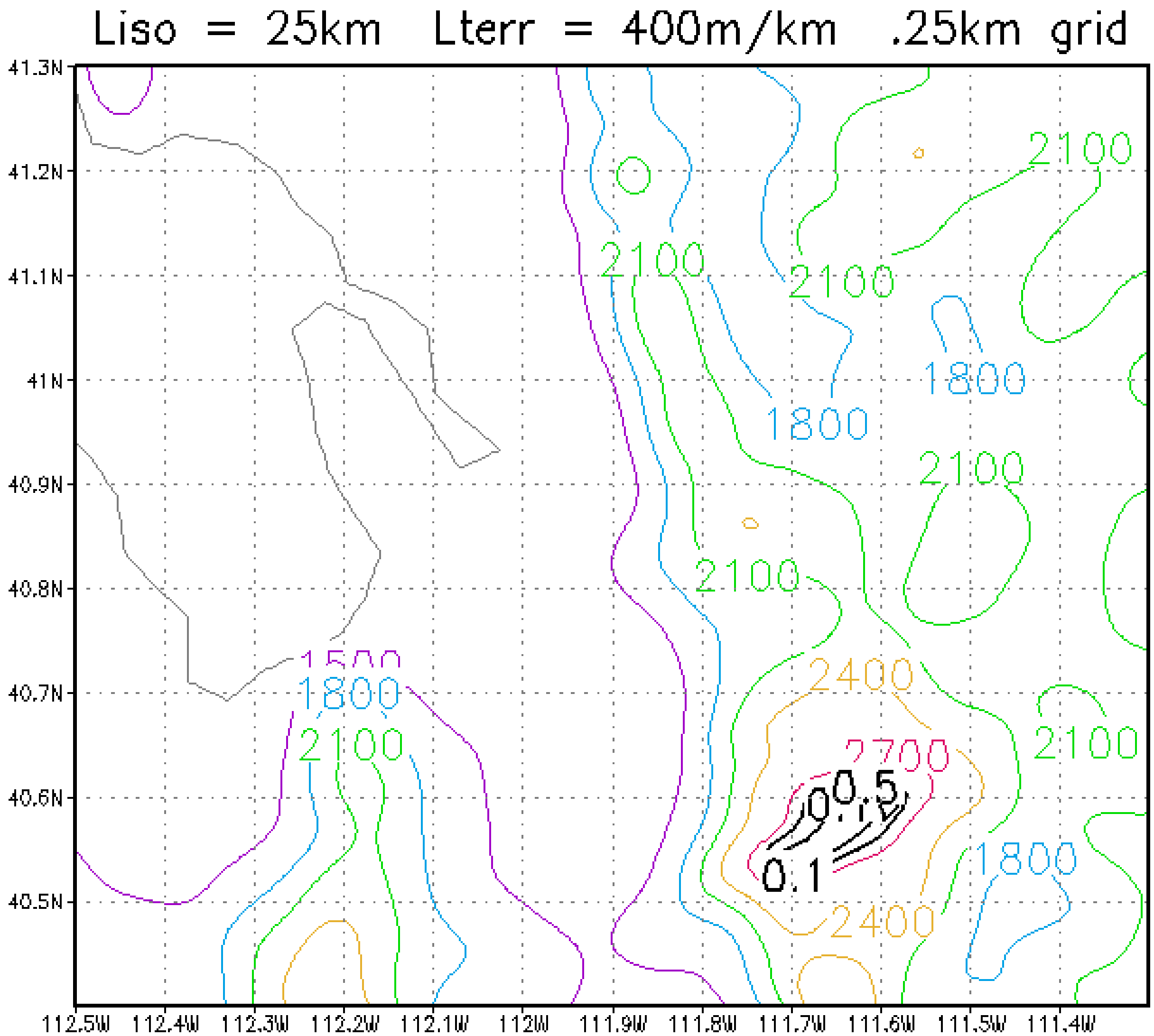
Anisotropic Error Correlation on Slope Plotted Over Utah Topography

ob's influence restricted to areas of similar elevation



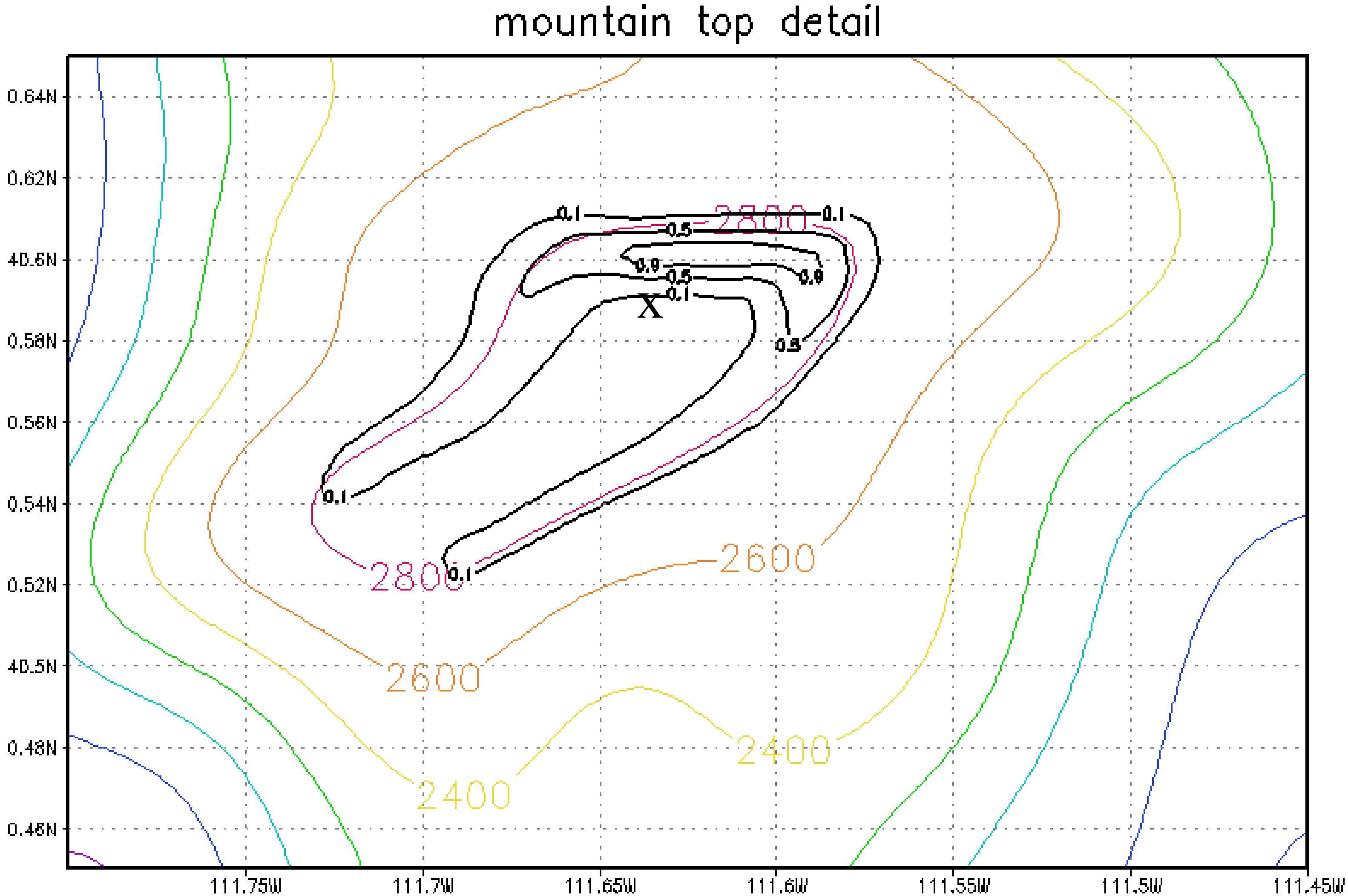
Anisotropic Error Correlation on Mt Top Plotted Over Utah Topography

ob's influence restricted to areas of similar elevation



Anisotropic Error Correlation on Mt Top Plotted Over Utah Topography

ob's influence restricted to areas of similar elevation



North American Mesoscale WRF Plans

- Date of Eta replacement moved to March 2006
- Increase horizontal resolution from 12 km to 10 km
- Move model top from 25 mb to 2 mb (will help assimilation of satellite radiances)
- Eta 3D-VAR to be replaced by Gridpoint Statistical Interpolation (GSI)
- Assimilate mesonets, GPS IPW, boundary layer Profilers and (hopefully) Level II radial velocity

North American Mesoscale WRF Plans

- Minimize transition tasks - produce complete set of existing NAM look-alike output
- Extend BUFR sounding files to 84 hour with only slight (5 minute?) delay compared to current 60 hr BUFR file delivery
- Replace non-WRF NMM applications in Fire Weather / IMET Support and On-Call Emergency Response nested runs
- Maintain ability to quickly run a replacement 12 km Eta (run 12 km EDAS in background mode) in the event of an ‘infrastructure related’ failure for which a quick solution is unlikely

PLANS FOR THE FUTURE

For each of the possible upgrades/phases of the CCS contract with IBM

North American Meso Guidance System

Prediction Model (DGEX included)	Analysis and Data Assimilation	Computer Phase
12 km 60 level Meso Eta earlier delivery	12 km 3DVAR improved use of surface observations	Current Phase I
10 km 60 level WRF 2mb top, nonhydrostatic dynamics, imp. physics called more frequently	10 km GSI analysis, 2 mb top, cloud analysis, AIRS, GOES imagery	Phase II
8 km 70 level WRF fire weather IMET support incorporated, improved physics	8 km, 88D reflectivity, hydrometeor analysis, cloud and aerosol absorption and scattering in radiative transfer	Phase III
6.5 km 85 level WRF .2 mb top, OCER incorporated, improved physics, ozone + aerosols	6.5 km .2 mb top, advanced 4DDA, NPP, NPOESS, IASI + air quality	Phase IV

HiResWindow and Fire Wx/IMET

HiResWindow	Fire Weather IMET Support	Computer Phase
8 km WRF 6 member ensemble	8 km nested WRF-NMM	Current Phase I
7 km WRF 8 member ensemble	6.5 km nested WRF with improved physics	Phase II
6 km WRF 10 member ensemble	5.5 km included in NAM-WRF run	Phase III
5 km WRF 12 member ensemble	4.5 km included in NAM-WRF run	Phase IV

Hurricane, Rapid Refresh & Air Quality

Hurricane Model	Rapid Refresh (RR)	Air Quality	Computer Phase
2 nests 18 + 55 km L 42, coupled Atl & Pac with GFS physics	20 km 50 level RUC 3DVAR	12 km Sfc ozone, New England	Current Phase I
2 nests 12 + 40 km L64 Hurricane-WRF & new ocean (HYCOM)	13 km 60 level RUC improved physics	10 km Sfc ozone National	Phase II
2 nests 8 + 30 km L64 Hurricane-WRF with 4DDA	10 km 60 level Rapid Refresh-WRF	8 km Sfc ozone, particulates	Phase III
2 nests 5 + 20 km L100 Hurricane-WRF with imp. physics & enhanced ocean model	8 km 70 level RR-WRF improved physics	6.5 km Sfc ozone, particulates	Phase IV