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Mesoscale Modeling Branch: Where We've Been and Where We're Going

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9 December 2003

Where the Nation's climate and weather services begin

T O P I C S

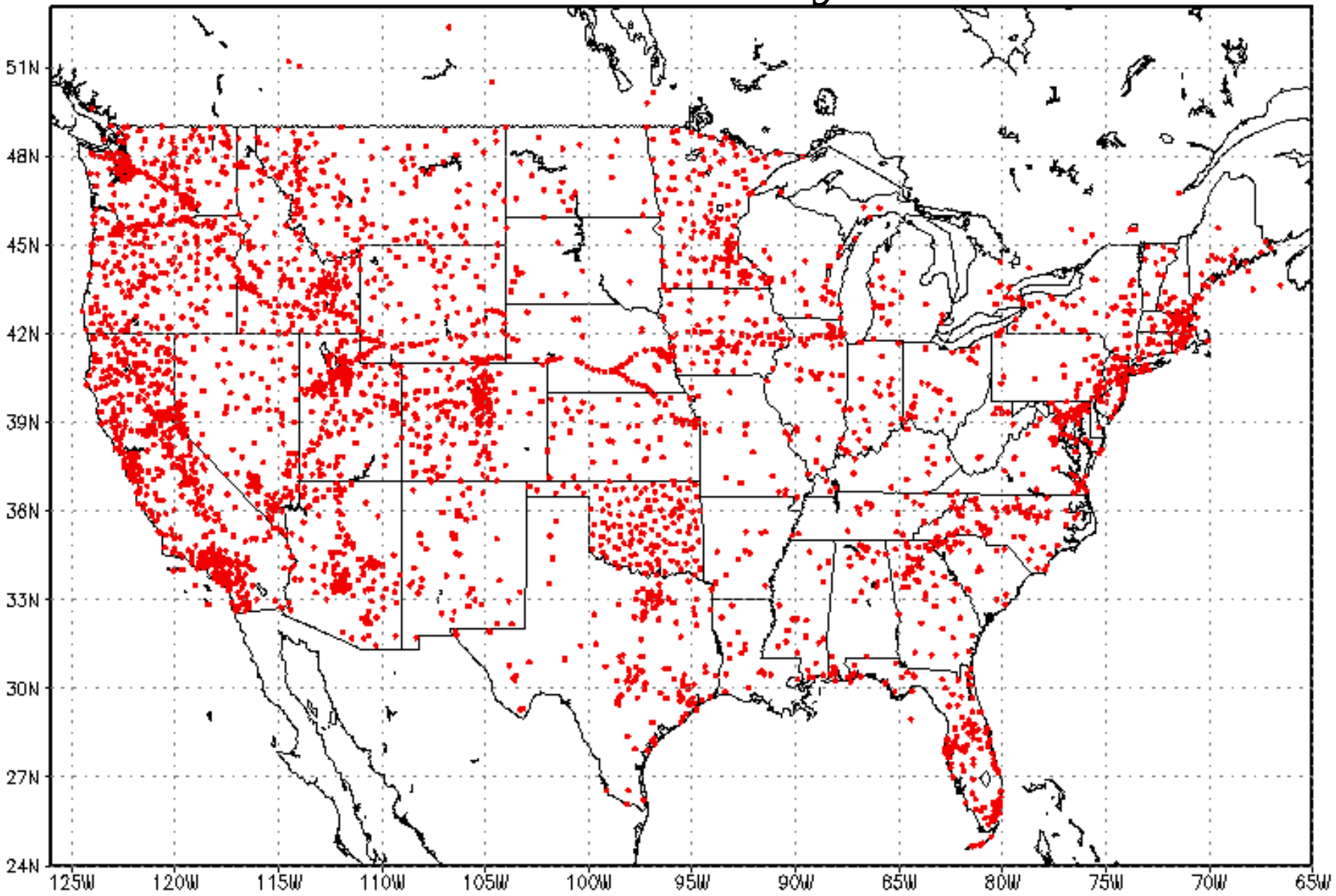
- Recent Changes in Operations
  - Observational & Modeling System
  - NMM Fire Weather / IMET Support – May+Oct
  - Eta Upgrade Package - July
  - SREF Upgrade – September
- Development & Other Highlights
  - Air Quality Forecast System - August
  - North American Regional Reanalysis – Jun-Sept
- Plans for the Future [most interspersed above]
  - Downscaling: Eta Extension and Analysis-of-Record

Observational Data Processing Implementations affecting the Eta

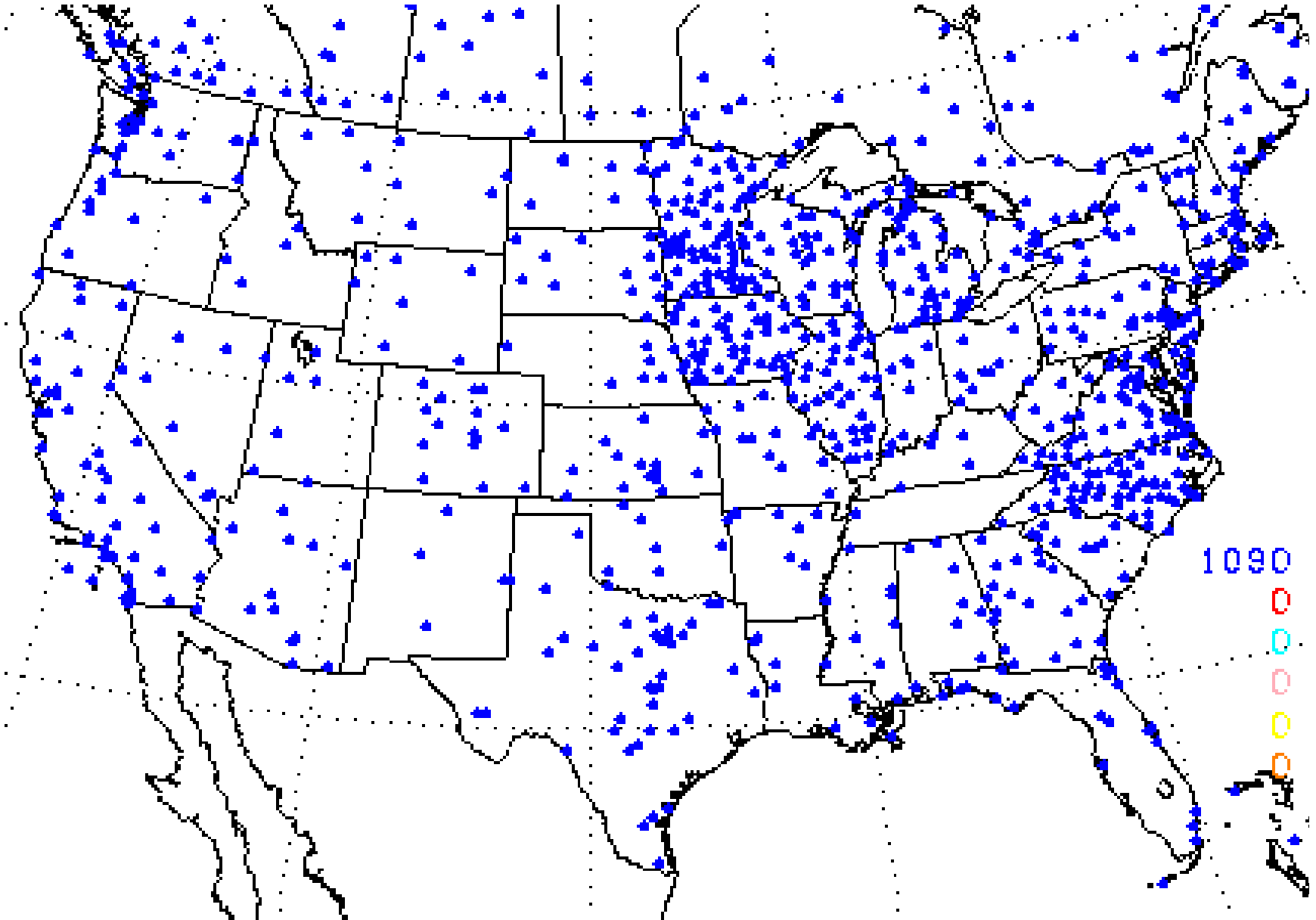
[part of what Dennis Keyser does]

- 10/12/2002 : CRISIS Restore the ingest of NOAA-14 HIRS-2 and MSU data after NESDIS's switch NOAA-14
- 11/05/2002 : CRISIS Correct error unpacking HIRS-3, AMSU-A and AMSU-B radiances when counts >32767
- 11/20/2002 : Upgrade of aircraft duplicate checking in data dump job
- 05/06/2003 : AIRS radiance data now ingested into the NCEP BUFR data base
- 06/24/2003 : **Data Restriction - Phase I** to isolate WMO Resolution 40 SYNOP reports & other restricted obs
- 07/07/2003 : Perform hourly dumps of GOES Single Field Of View cloud top data and Level III WSR-88D NEXRAD radial wind superobs for use in EDAS as part of Eta Spring Bundle
- 08/12/2003 : **Data Restriction - Phase II** to strip off restricted data (i.e.Res 40 SYNOP, AMDAR and E-ADAS BUFR format ADSAR/ACARS, MDCRS ACARS & all Mesonet types), write resulting unrestricted files to /com directories for use by unregistered users
- 08/19/2003 : **Data Restriction - Phase III** read permission on files w/ restricted obs ONLY for registered users
- 08/28/2003 : CRISIS to correct error in calculation of RAOB balloon drift time when below ground mandatory level heights were reported - affected the sun angle calculation in the radiation correction step.
- 09/09/2003 : CRISIS to correct error in the report date-time calculation to allow proper use of marine data subjective quality flags
- 11/04/2003 : Unified BUFRLIB merges unique components from 3 versions (decoder, verification and ENDIAN-independent versions) into fully portable version for NCEP and for WRF. Adds DOCBLOCKS and more descriptive error messages as well as many other changes to existing routines and the addition of new routines. Necessary step for ultimate use in operational data assimilation of mesonet, GPS-IPW, RASS, CAP and boundary layer wind profiler, NEXRAD Level II.5 superobs and AIRS radiances (upcoming JIF package to be submitted December 2003).

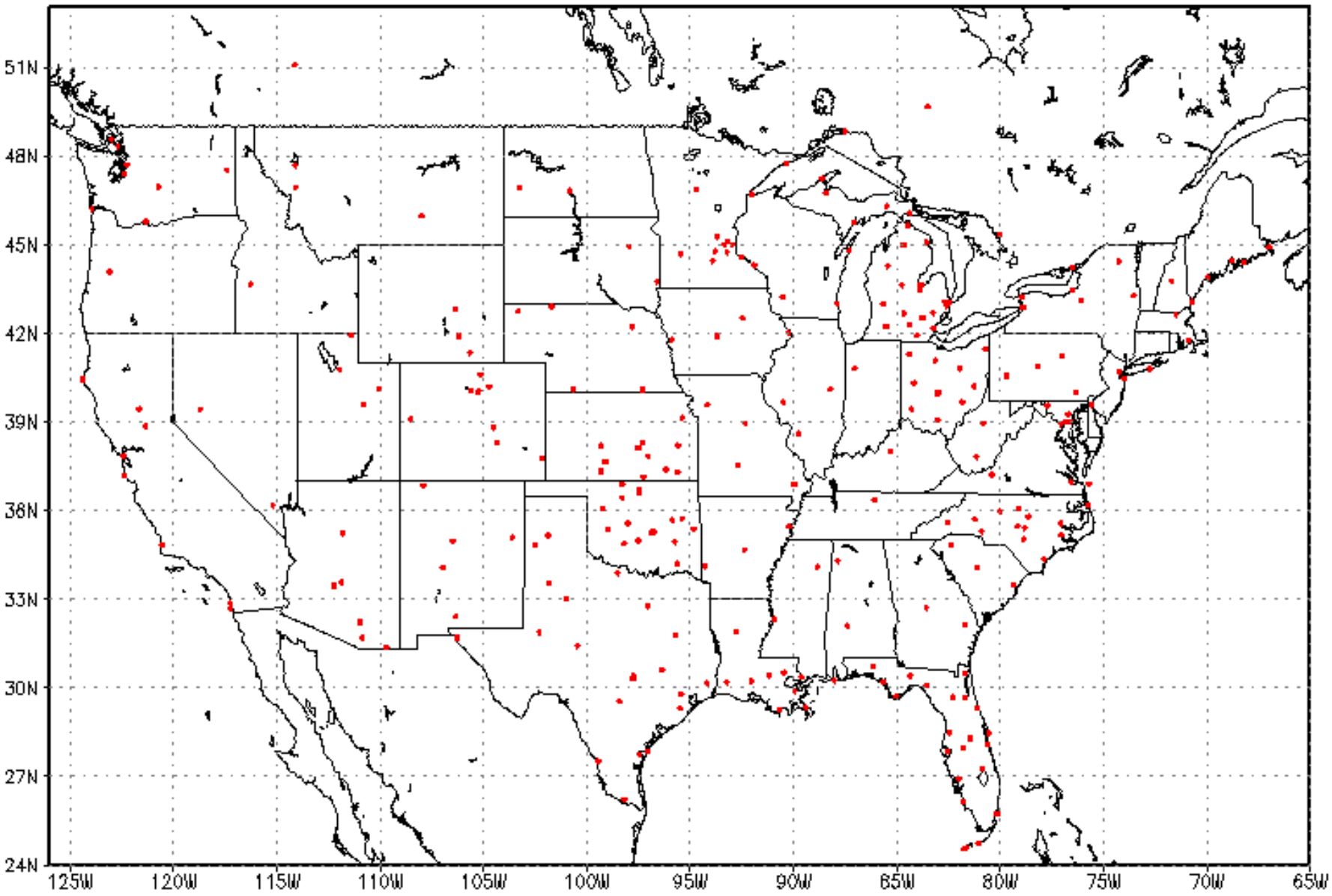
Mesonet (non-AWS) Surface Ob Density



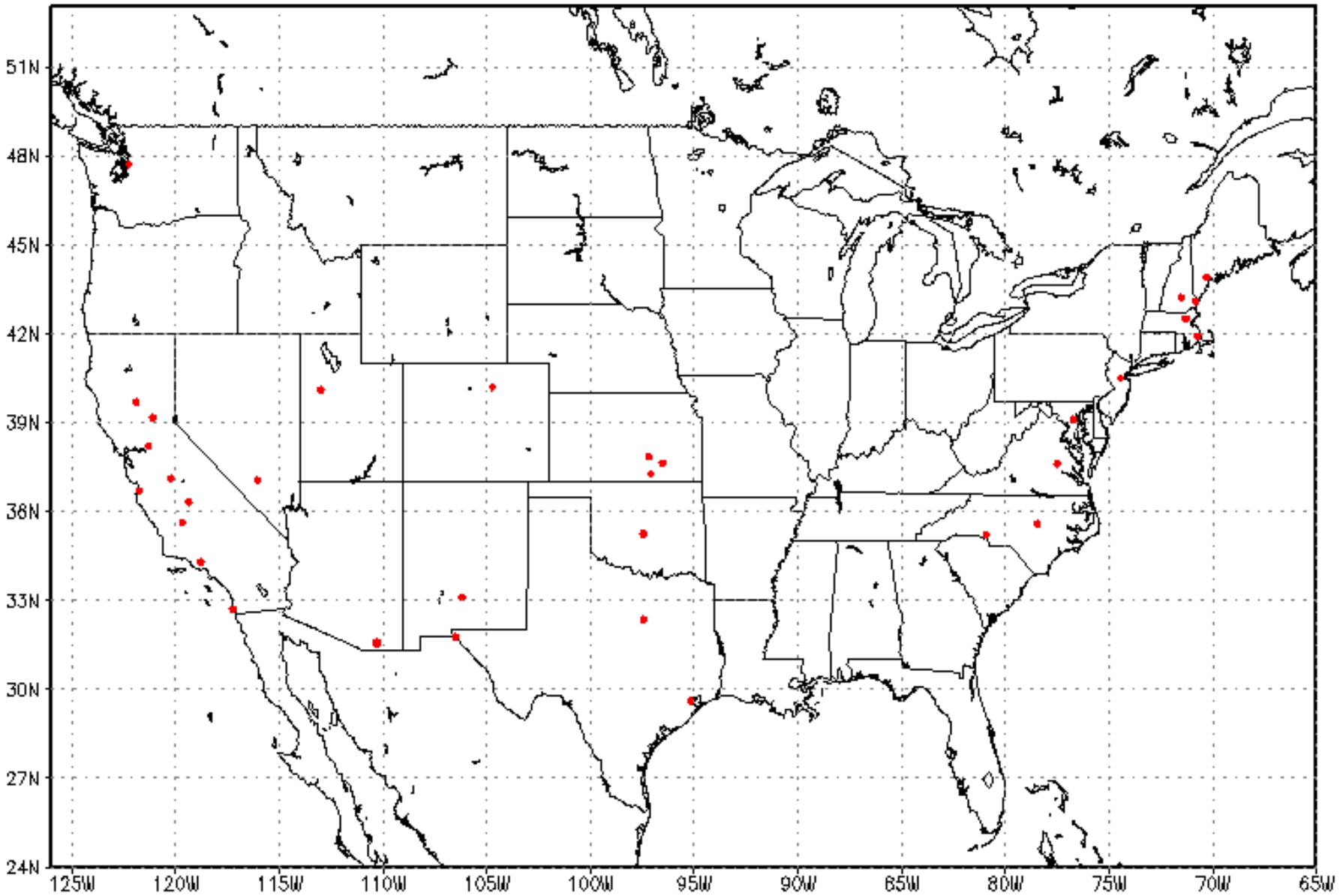
METAR Surface Ob Density



GPS IPW (Integrated Precipitable Water) Ob Density



Boundary Layer Profiler Ob Density



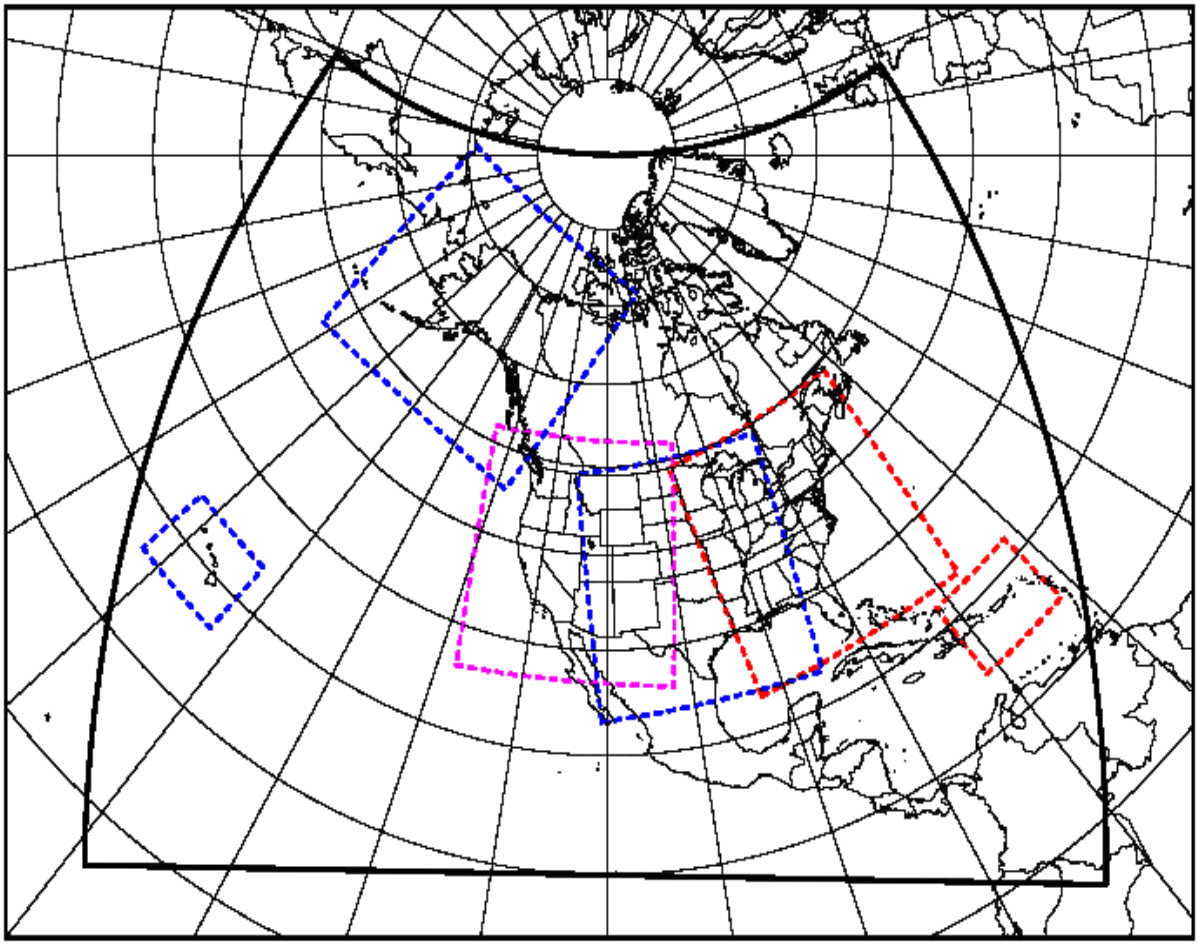
Modeling System Implementations affecting the Eta, NMM or RUC

[part of what Geoff Manikin & Eric Rogers do]

- 10/1/02 : RUC Land sfc model modified to reduce cold bias over patchy snow cover; short wave radiative tendency error corrected; precip type left unsmoothed on 40 km output grid
- 1/7/03 : Corrected error in list of Julian dates
- 5/27/03 : 3DVAR data assimilation replaced OI
- 7/8/03 : 00 hr bufr files fixed to use 'B' analysis
- 9/24/03 : Analysis change to lower some QC thresholds for observations and to flag land stations located at model water grid points
- 10/6/03 : Corrected errors in max wind level due to cubic spline computation sensitivity in situations where model levels are very close
- 10/10/03 : Added check in boundary condition generation code in which Eta pressure level output is interpolated to RUC theta levels to prevent a denominator term from going to 0
- 11/12/02 : Fix for Stage IV precip analysis to handle duplicate multi-sensor precip estimates from River Forecast Centers
- 11/22/02 CRISIS : Turn off NOAA-16 AMSU-A radiance channels 9-11
- 5/19/03 : Implement Fire Weather run
- 7/8/03 : **Eta "SPRING" BUNDLE**
- 7/22/03 : Fix to code reading GOES cloud top
- 7/29/03: Eta product generator upgrade
- 9/8/03 : Eta product changes including addition of Hawaiian aviation FD wind/temps levels @ 305m, 457m, 610m, 4572m
- 9/10/03: Surface temps turned off in Eta 3DVAR
- 10/7/03: Mass conserving lateral boundary treatment implemented for NMM nests
- 10/29/03 CRISIS : Turn off NOAA-17 AMSU-A radiance channels due to degraded quality

HiResWindow Fixed-Domain Nested Runs

- Routine runs made at the same time every day
- 00Z : Alaska-10 & Hawaii-8
- 06Z : Western-8 & Puerto Rico-8
- 12Z : Central-8 & Hawaii-8
- 18Z : Eastern-8 & Puerto Rico-8
- This gives everyone a daily high resolution run when <2 hurricane runs need to be made



http://www.emc.ncep.noaa.gov/mmb/mmbpll/nestpage/Alaska-10km soon to be slightly smaller 8km domain

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

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Where the Nation's climate and weather services begin

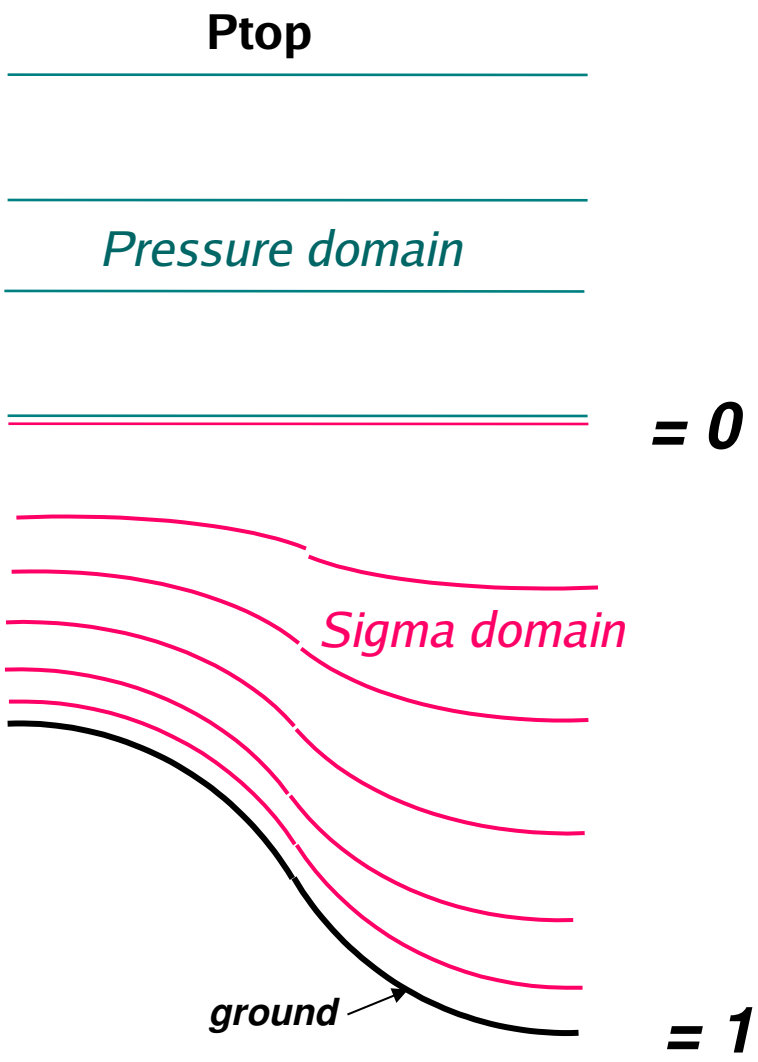
Nonhydrostatic Mesoscale Model (NMM)

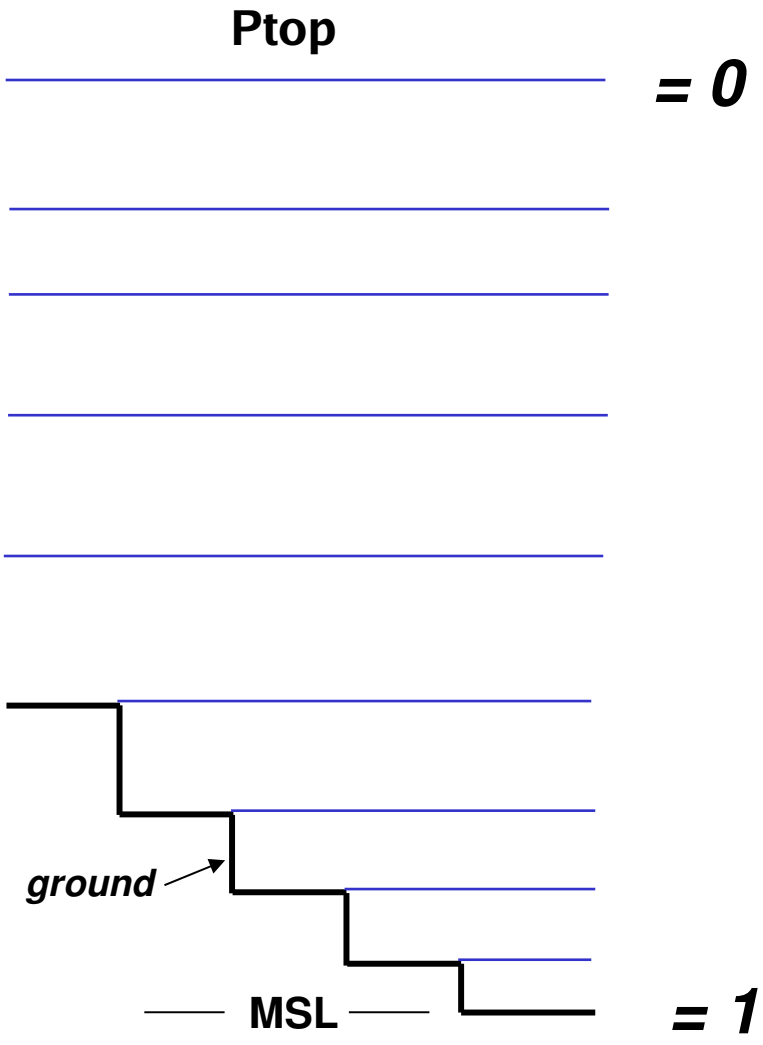
- See Janjic, Gerrity,and Nickovic, 2001 for model equations, solution techniques & other test results [MWR,Vol. 29, No. 5, 1164-1178]
- Highly refined version of nonhydrostatic option released in May 2000 upgrade to NCEP's workstation Eta
- NMM retains full hydrostatic capability
  - Incorporate nonhydrostatic 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

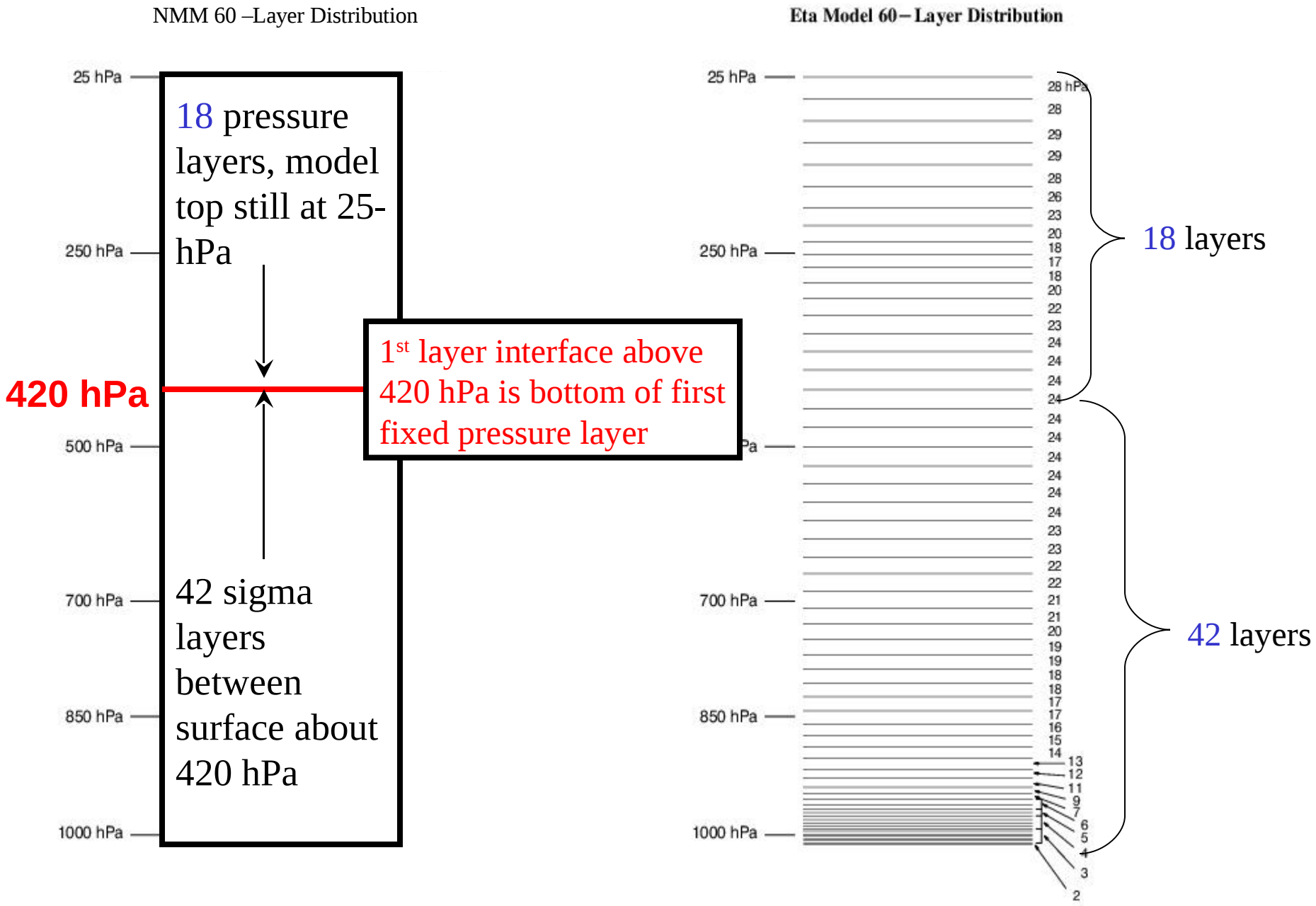
Feature	Meso Eta Model	Nonhydrostatic Meso Model
Dynamics	Hydrostatic	Hydrostatic plus complete nonhydrostatic corrections
Horizontal grid spacing	12 km E-grid	8 km E-grid for FireWx/IMET 4 km E-grid for Homeland Security
Vertical coordinate	60 step-mountain eta levels	60 sigma-pressure hybrid levels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

Hybrid versus Step (Eta) Coordinates





NMM vertical domain compared to Eta



Nonhydrostatic Mesoscale Model Feature Comparison With Meso Eta

Feature	Meso Eta Model	Nonhydrostatic Meso Model
Dynamics	Hydrostatic	Hydrostatic PLUS full set of nonhydrostatic corrections
Horizontal Advection spatial scheme	Janjic conservative T, u, v, TKE; shape preserving for q and total condensate	Janjic conservative T, u, v; shape preserving for TKE, q, and total condensate

Nonhydrostatic Mesoscale Model Feature Comparison With Meso Eta

Feature	Meso Eta Model	Nonhydrostatic Meso Model
Vertical Advection	Euler backward T, u, v, TKE; shape preserving conservative for q and condensate	Shape preserving conservative for all: T, u, v, TKE, q and condensate
Pressure gradient force	Forward backward	Forward backward with adjustment for sigma
Advective time scheme	Euler backward	Adams - Bashforth

Nonhydrostatic Mesoscale Model

Damping Features Comparison With Meso Eta

Damping Features	Meso Eta Model	Nonhydrostatic Meso Model
Vertical advection	Euler backward is damping	Shape preserving scheme is not damping
Advective time-step	Euler backward is damping	Adams - Bashforth is not damping
Divergence damping	Coeff = 6.5 Grid-coupling=1.	Coeff = 15 Grid-coupling < 0.5
Lateral diffusion	Coeff = .25 with no limit on deformation	Coeff = .10 with limit on deformation

Nonhydrostatic Mesoscale Model

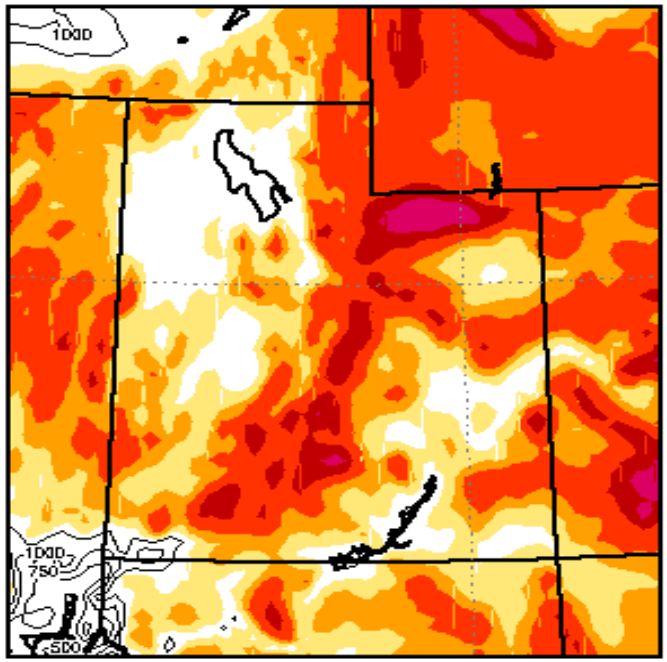
Physics Features Comparison With Meso Eta

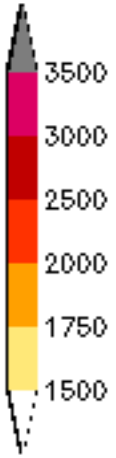
Physics Feature	Meso Eta Model	Nonhydrostatic Meso Model
Turbulent mixing	Mellor-Yamada Level 2.5 dry	Mellor-Yamada Level 2.5 including moist processes
Surface exchange	…+ Paulson functions	…+ Holtslag and de Bruin functions
Land-sfc	NOAH LSM	NOAH LSM
Gridscale	Ferrier	Ferrier
Convective	B-M-J	B-M-J’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

Positive Aspects of HiResWindow/NMM for FireWx

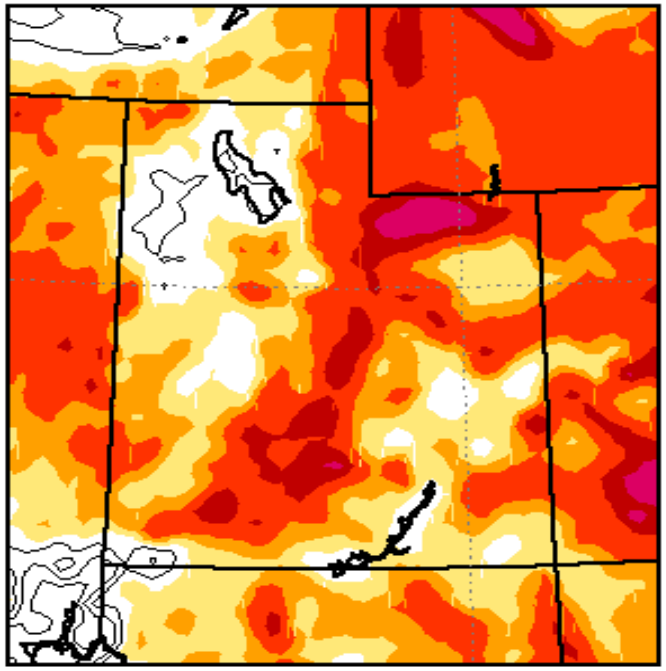
- Higher resolution and use of sigma-pressure vertical coordinate should yield
  - Better low level winds (especially vs Eta)
  - Better low level temperatures
  - Better low level dew points
- Nonhydrostatic dynamics should yield
  - Better predictions in cases with strong vertical circulations / accelerations

SFC HGT WEST08

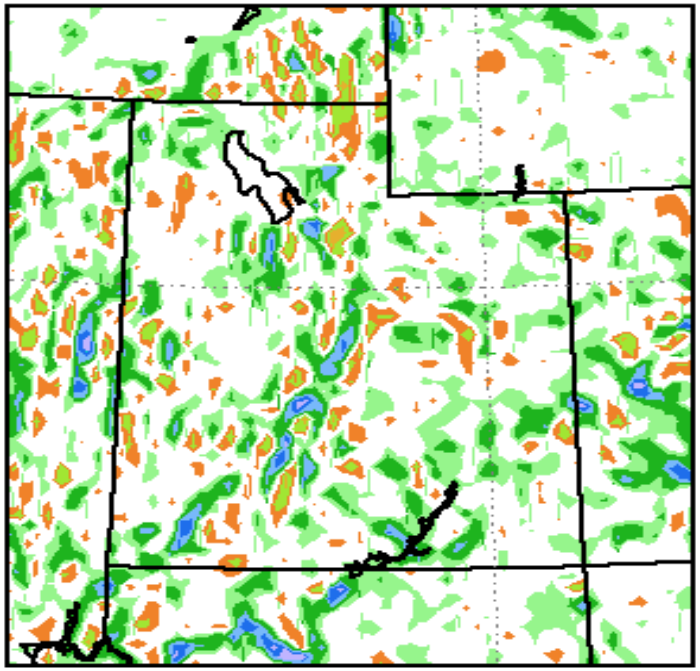


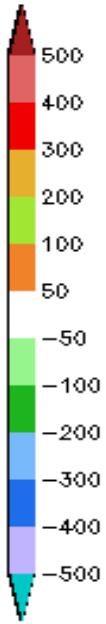


SFC HGT ETA12

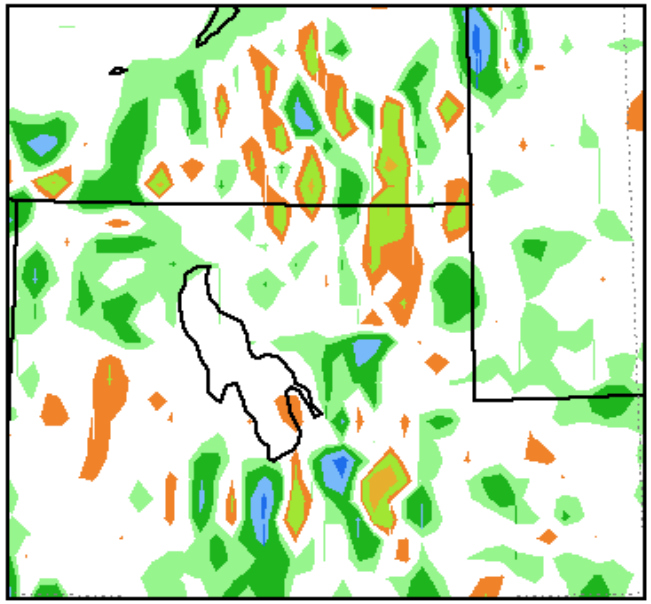


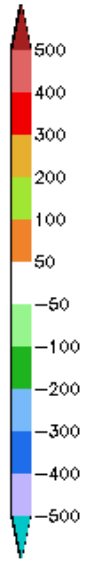
SURFACE HEIGHT WEST8–ETA12



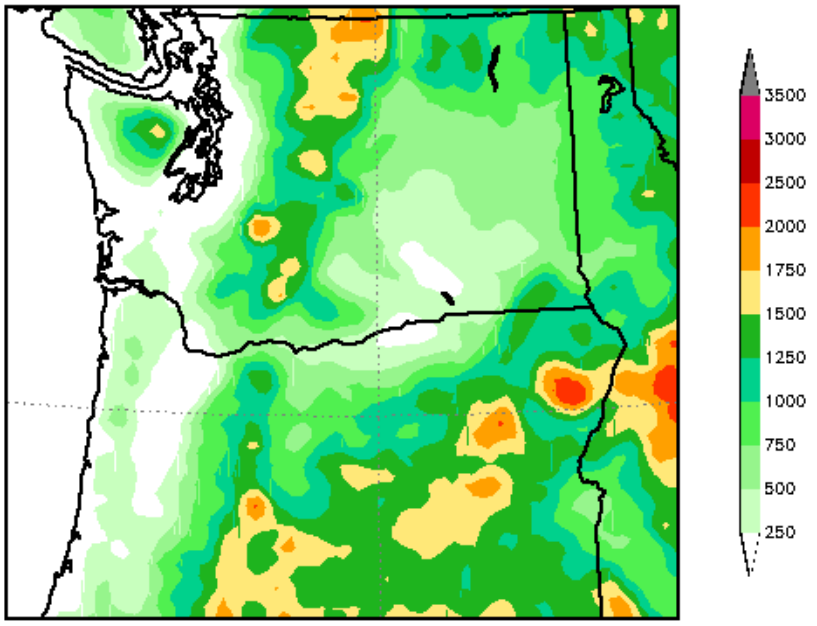


SURFACE HEIGHT WEST8–ETA12

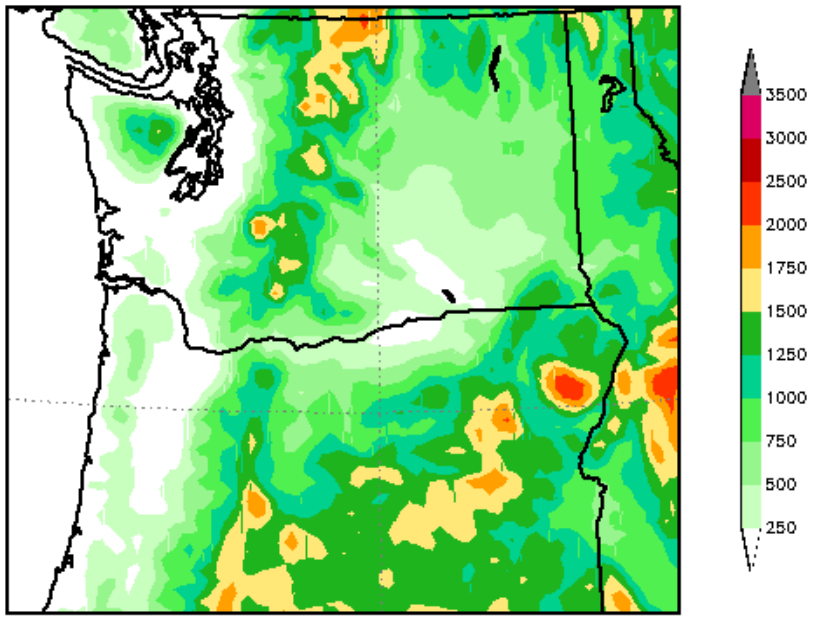




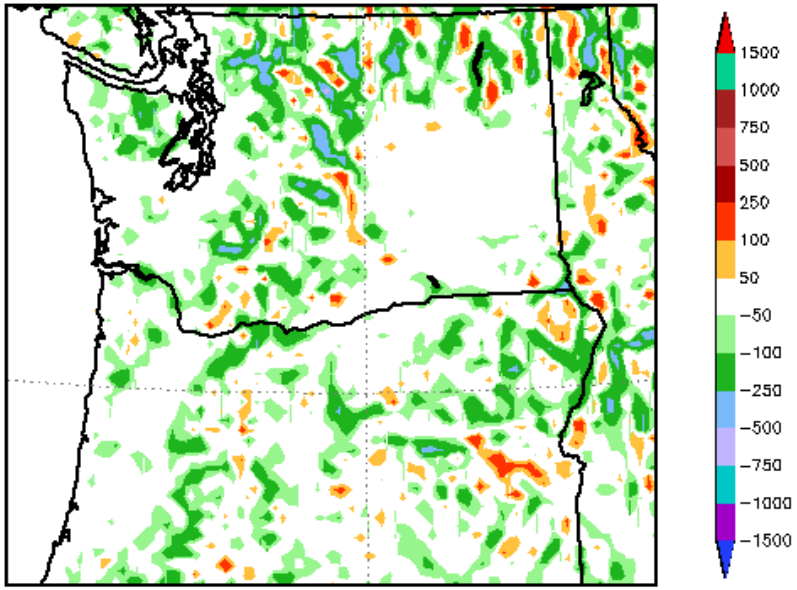
SFC HGT ETA12



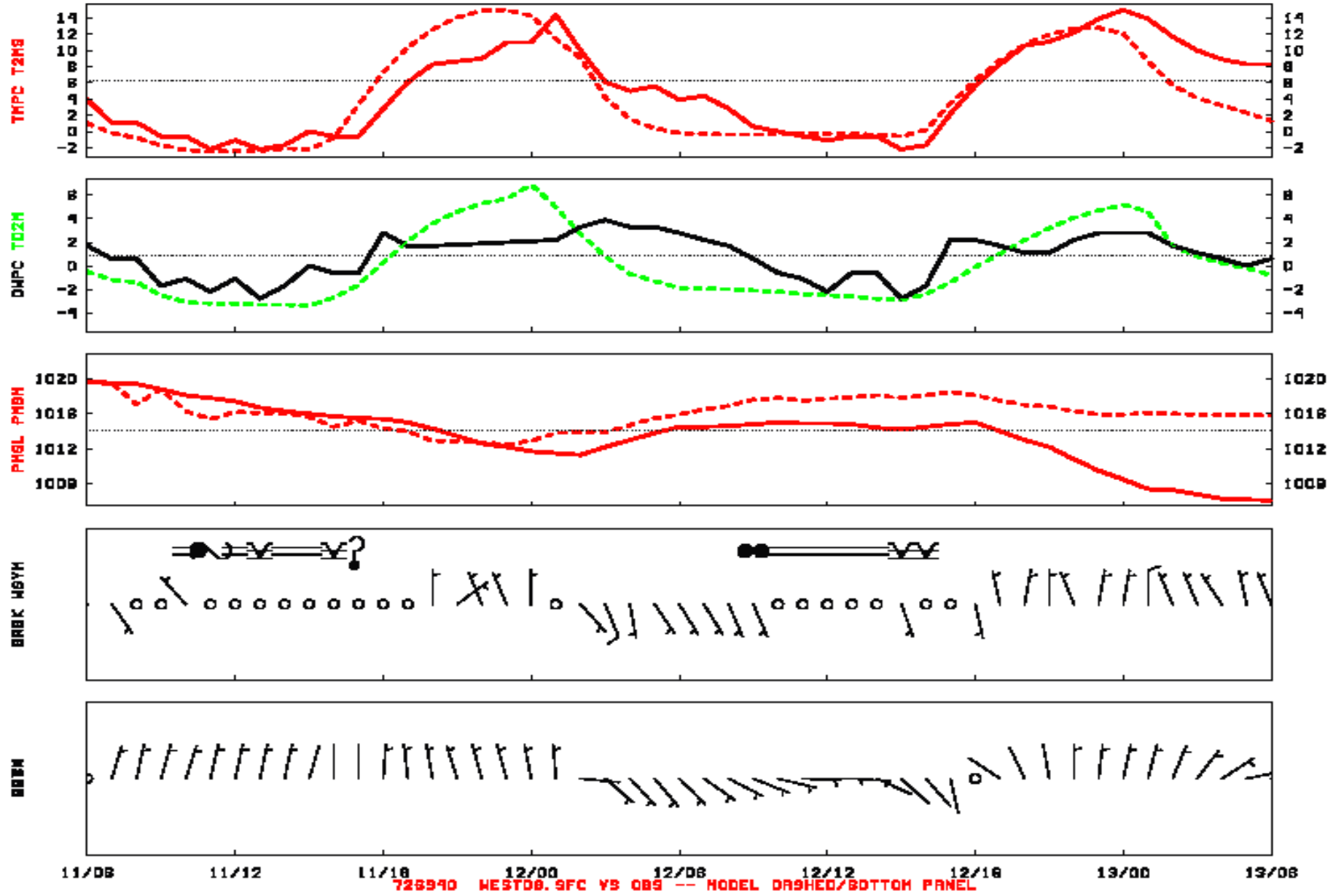
SFC HGT WEST08



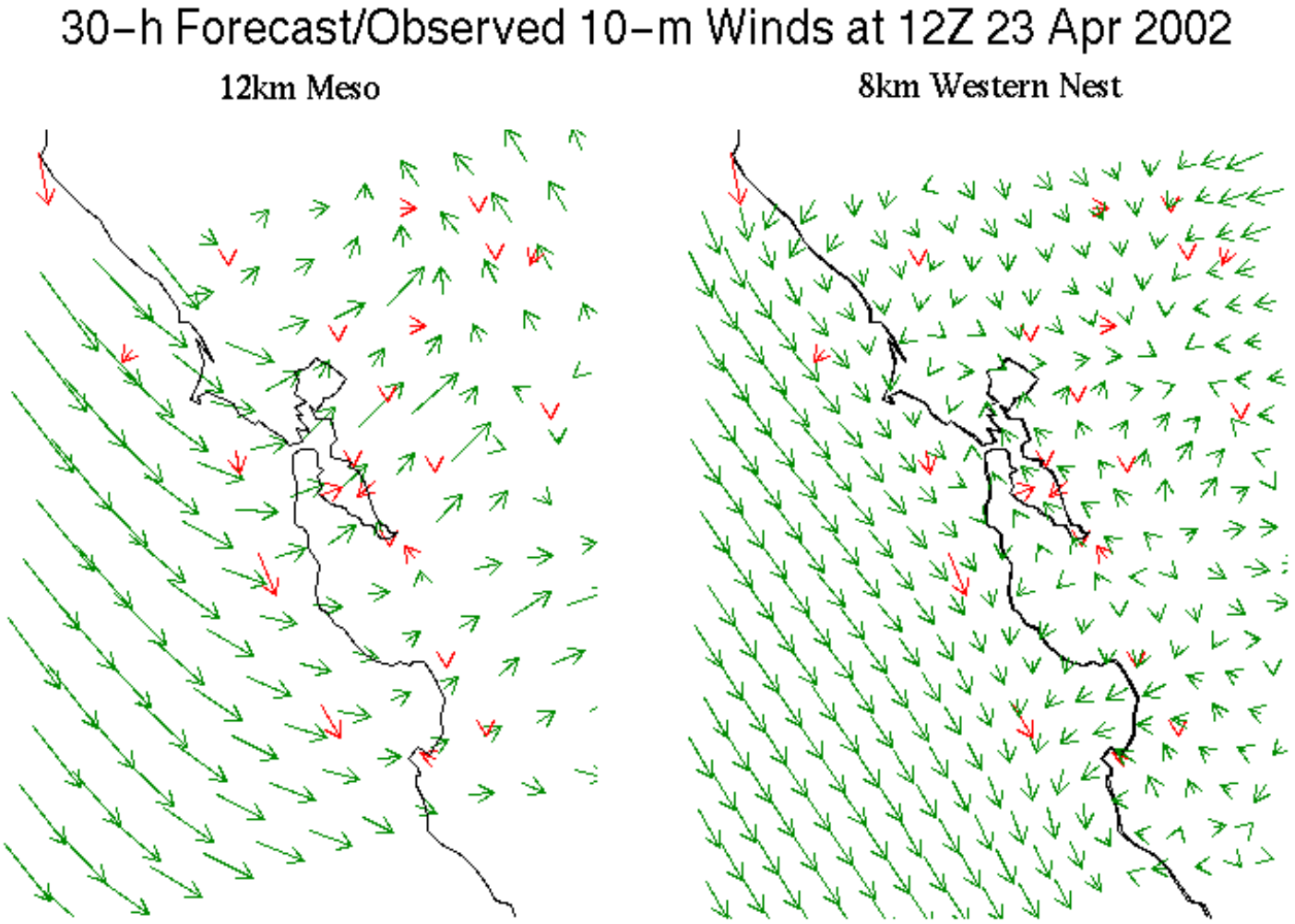
SURFACE HEIGHT WEST8–ETA12



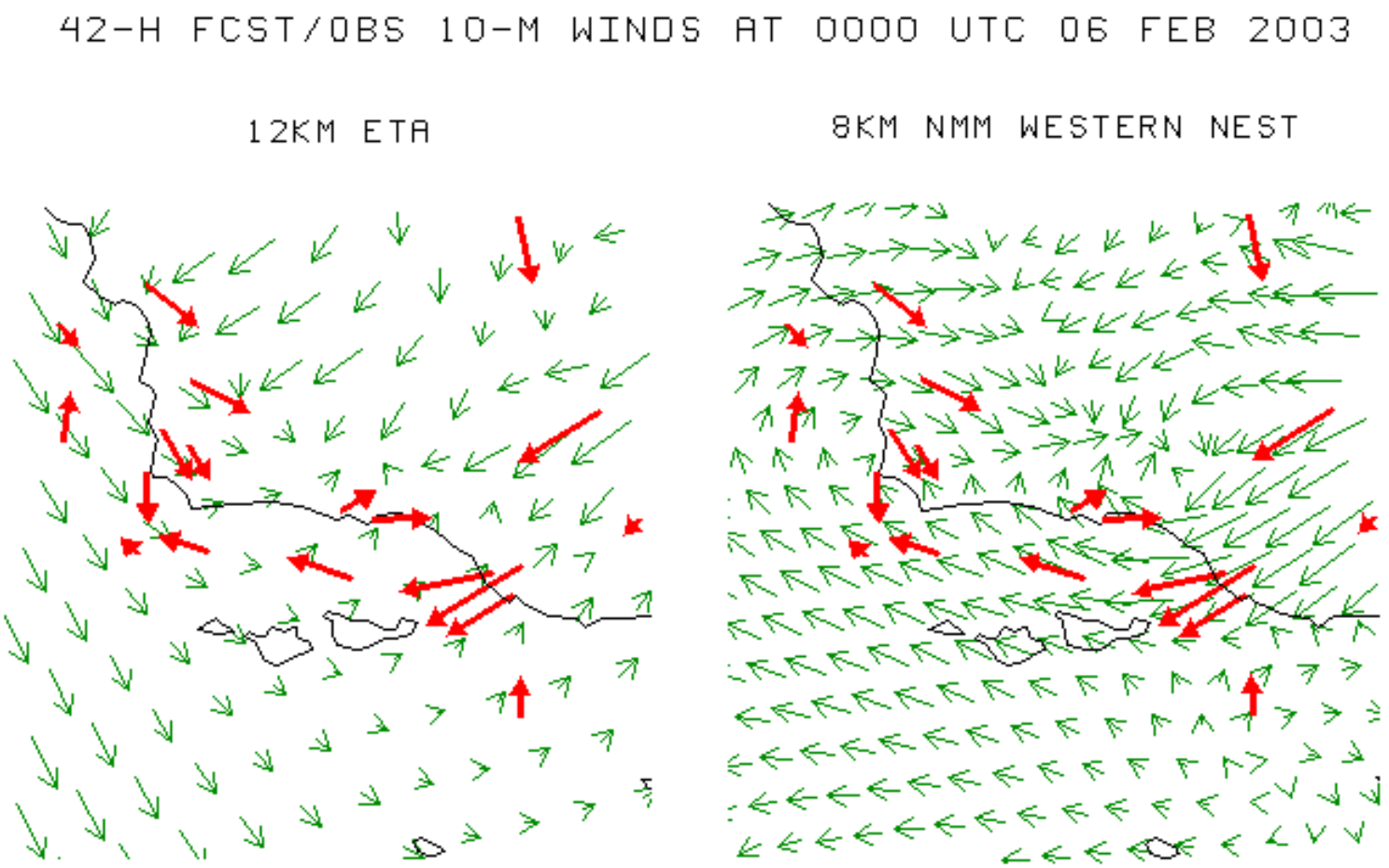
Salem, OR West-08 vs Obs from 06Z 2/11/03



12 km Meso Eta vs 8 km NMM Winds

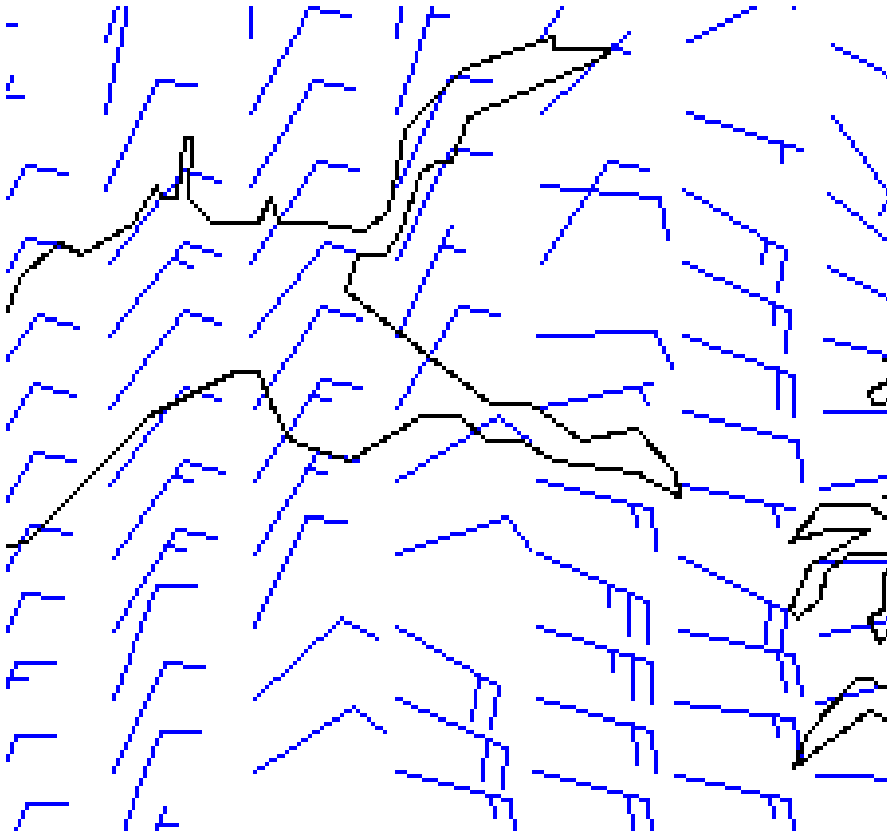


12 km Eta vs 8 km NMM Winds

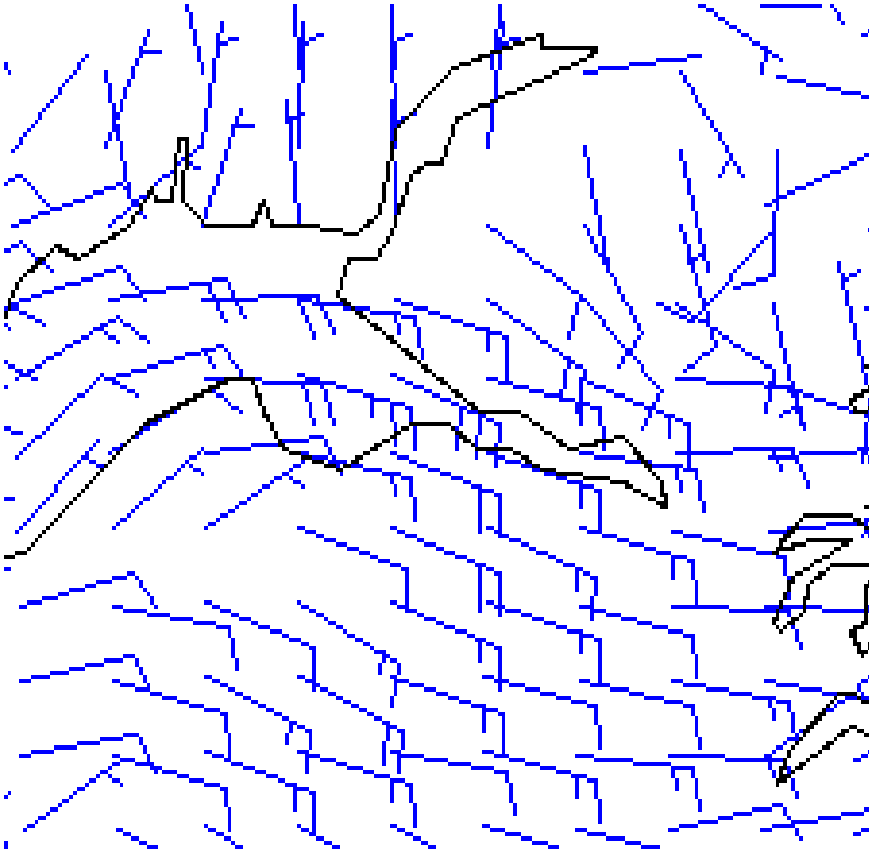


Alaska Case Eta-12 vs NMM-4
17 March 2002

Eta-12



NMM-4



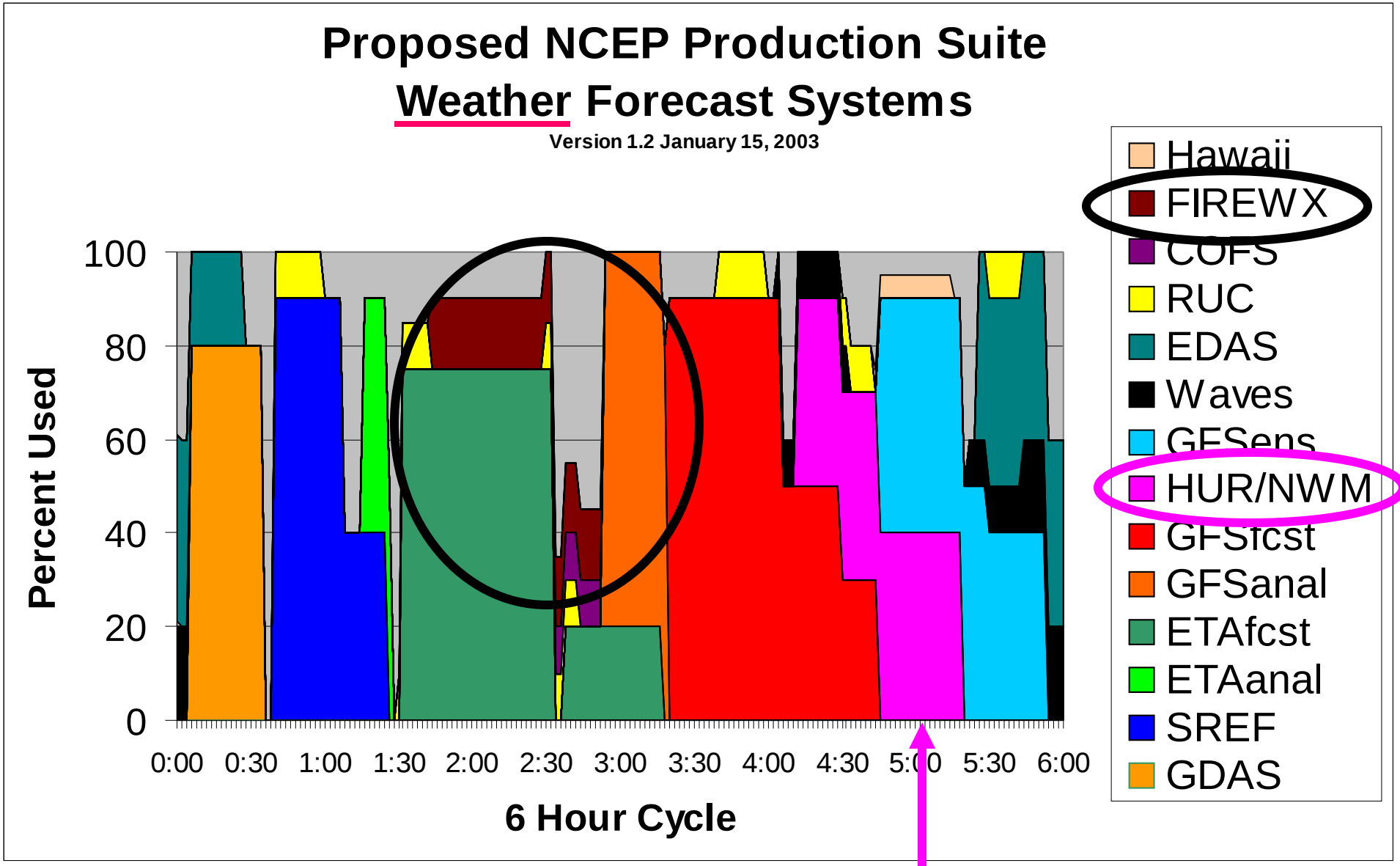
Negative Aspects of HiResWindow for FireWx

- One 48 hour run per day, BUT fire weather guidance to be used for strategic (1-2 day) planning not for tactical purposes
- Reliability - fire season nearly same as hurricane season so there will likely be conflict between NHC requests for runs of the GFDL hurricane model and need for HiResWindow to support fire weather
- Timeliness – HiResWindow runs after GFS

Vastly Improved Option Implemented By NCEP in May 2003

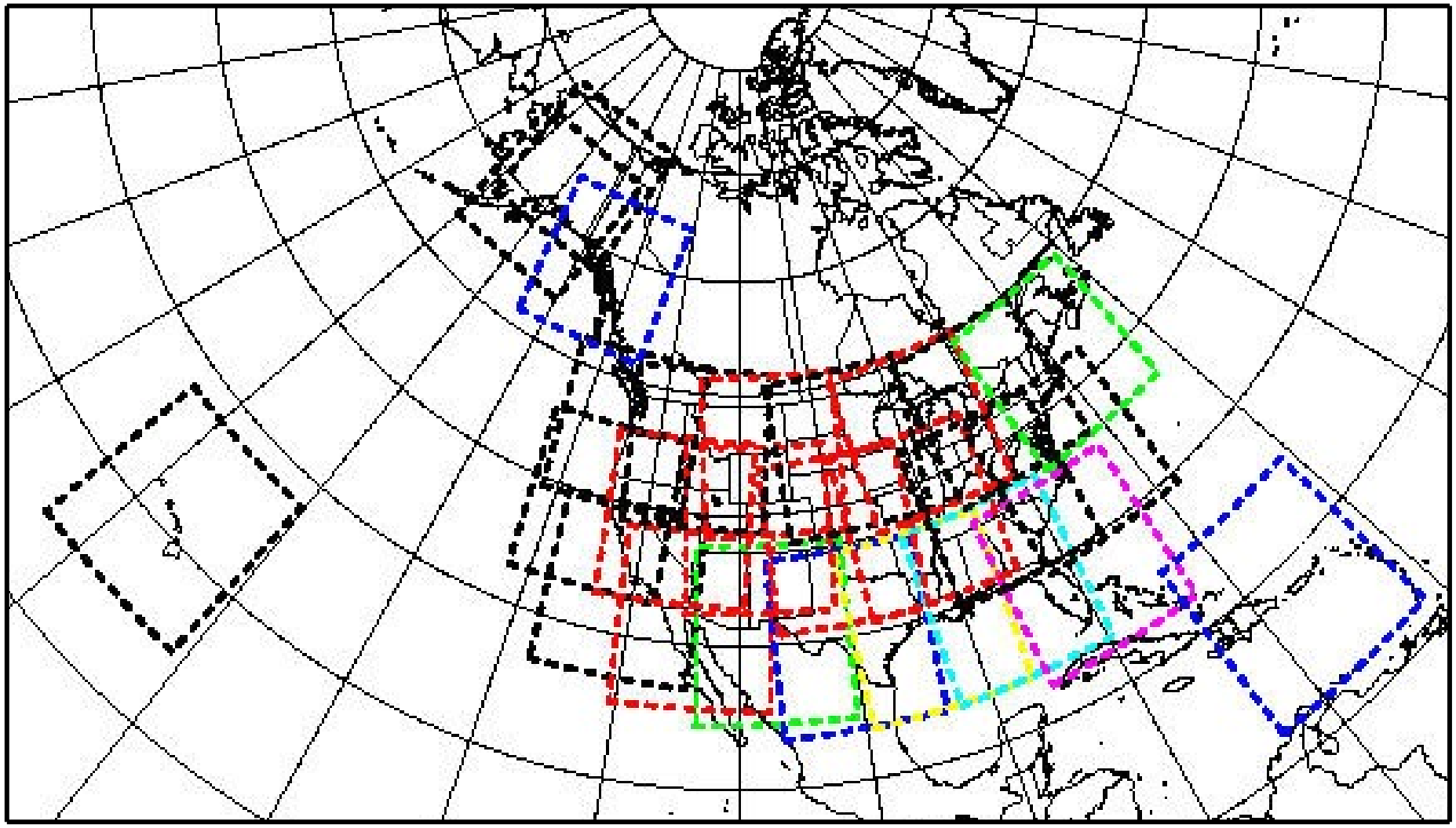
- EMC gave up some growth potential for Eta and built a Fire Wx/IMET Support run designed to run over the top of the Eta at all four runtimes of 00z, 06z, 12z & 18z
- Better than using HiResWindow because it has no conflict with hurricanes
- Established reduced domain nests patterned after NCEP's On-Call Emergency Response capability for Homeland Security
- Nests to run at 8 km resolution like the HiResWindow
- Only downside is smaller domain than HiResWindow
- Fixed lateral boundary problem in October which was causing height bias

Wx Production Suite Made Up of Four Uniform Cycles per Day



Hurricane & Nested Window Model (HiResWindow) occupy same run slot

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



Fire Weather / IMET Support Run

- SDM receives request for run via coordination call with Boise, WR & SPC [et al?]
- Runs are made within 4 dedicated run slots at 0000z, 0600z, 1200z and 1800z running over the top of the Eta
- 8 km NMM run produces 3 hourly output grids
- Output grids (mapped to look just like HiResWindow) picked up by WR [et al?], clipped to relevant subregion and prepared for transmission to IMET laptops using same FX-NET procedure developed for Olympics.
- SPC gets their grids directly from NCEP

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

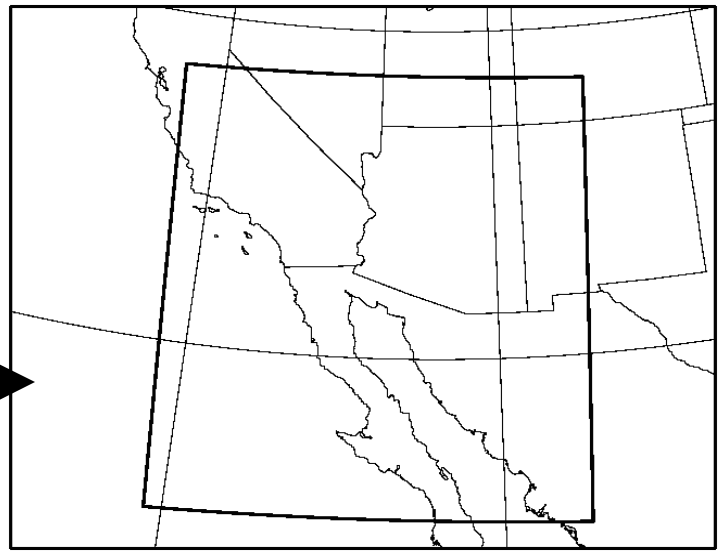
xx = 01 - 26 (geographic location)

Filenames follow the convention:

fh.{hhhh}_tl.press_gr.awpreg where

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

File on TOC with gif of region



Fire Weather / IMET Support Run

- Unfortunately, to view these runs required an upgrade to FX-NET which was deemed too risky in middle of Fire Weather season - so these runs were not used by IMETs in 2003
- These runs were used by SPC in making their Fire Weather Outlooks
- These runs are being used by NCEP's HPC and OPC [et al?] during 2003-2004 Winter Weather Experiment
- We would like to increase resolution of these runs but not if that requires another upgrade to FX-NET – working with WR & Boise

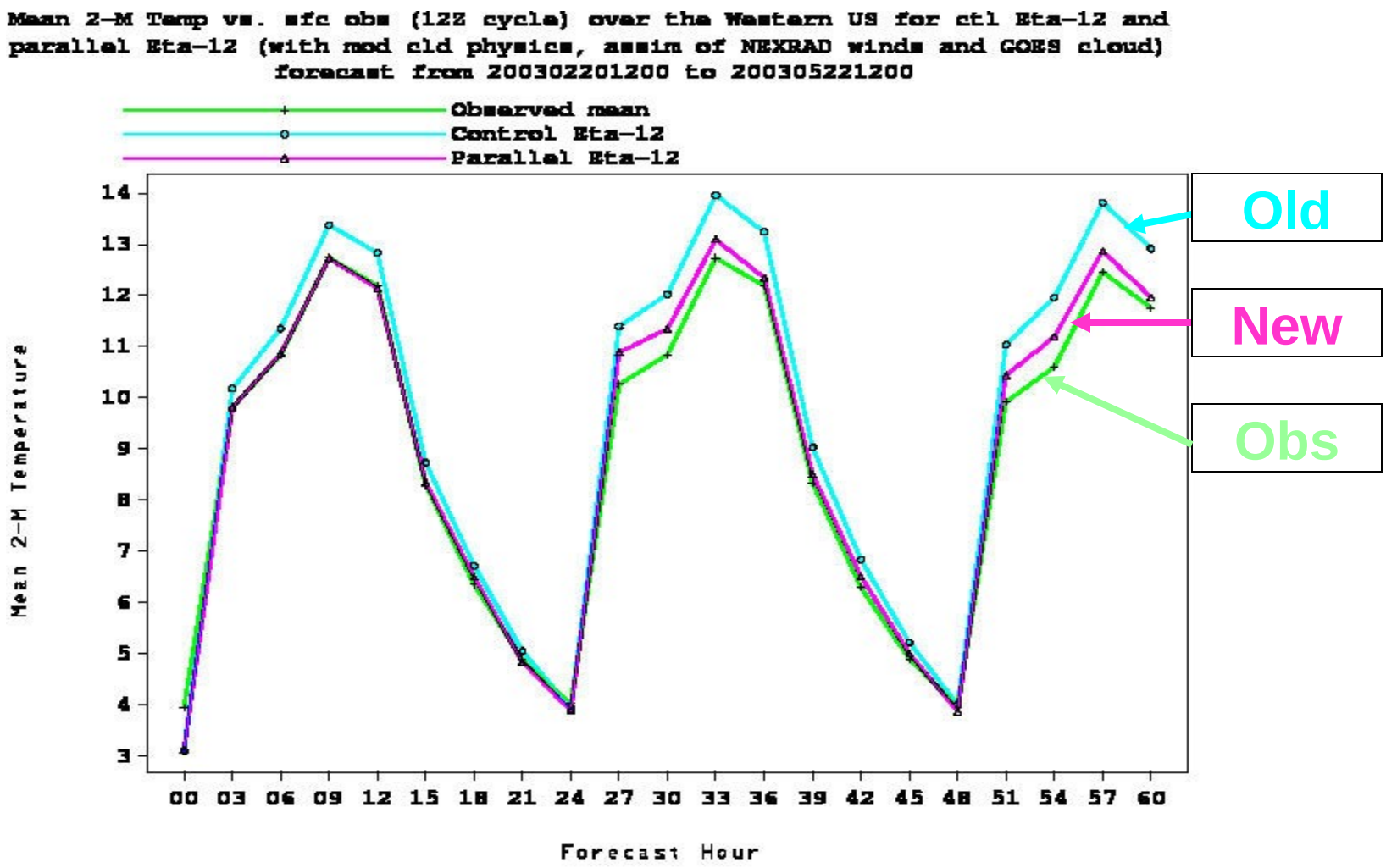
July Upgrade Package for Eta-12 (Rogers)

- Gridscale cloud & precipitation (Ferrier)
  - Begin proper cycling of total condensate & ice/water rain/snow ratios
  - Upgrade microphysics and improve cloud - radiation interaction
- 3DVAR analysis (Parrish)
  - Add direct analysis of WSR-88D radial velocity from NWS Multicast
  - Upgrade radiance processing – begin use of NOAA-17 – 20x more
- Precipitation assimilation (Ying Lin)
  - Assimilation of GOES cloud top pressures
  - Assimilate Stage IV instead of Stage II hourly precip
- Increased output frequency and content (Manikin +)

http://wwwt.emc.ncep.noaa.gov/mmb/tpb.spring03/tpb.htm

http://wwwt.emc.ncep.noaa.gov/mmb/mmbpll/etapllsup12.etax/

Surface Temperature Response: Reduced Daytime Hot Bias



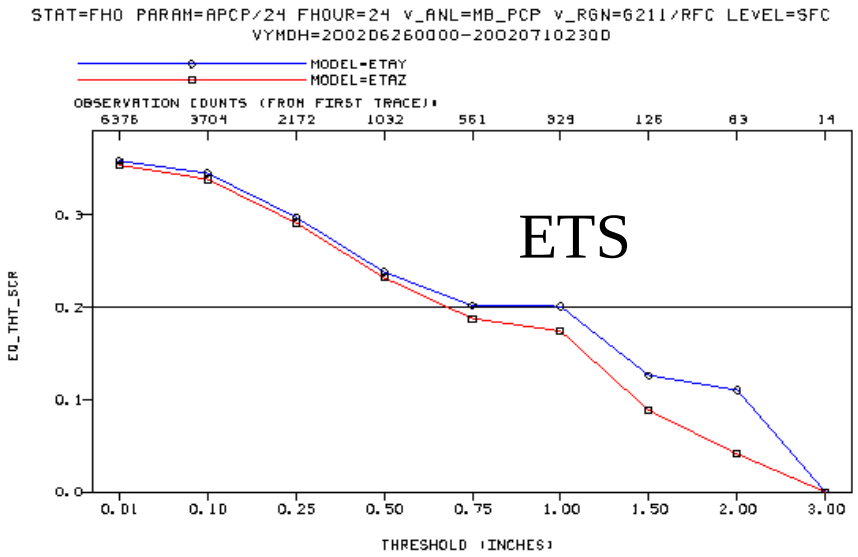
True for East and West and for both 00z and 12z runs.

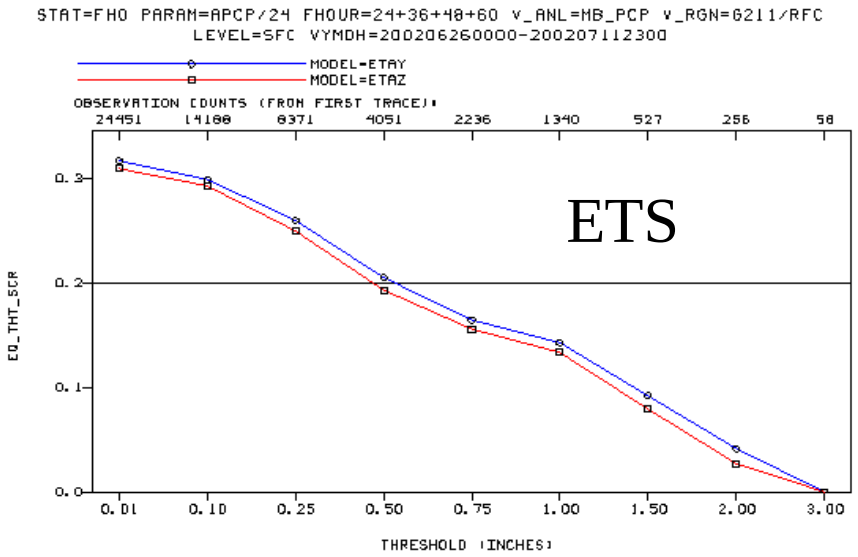
Impact of Use of Cloud-Top on 24 hr QPF Scores

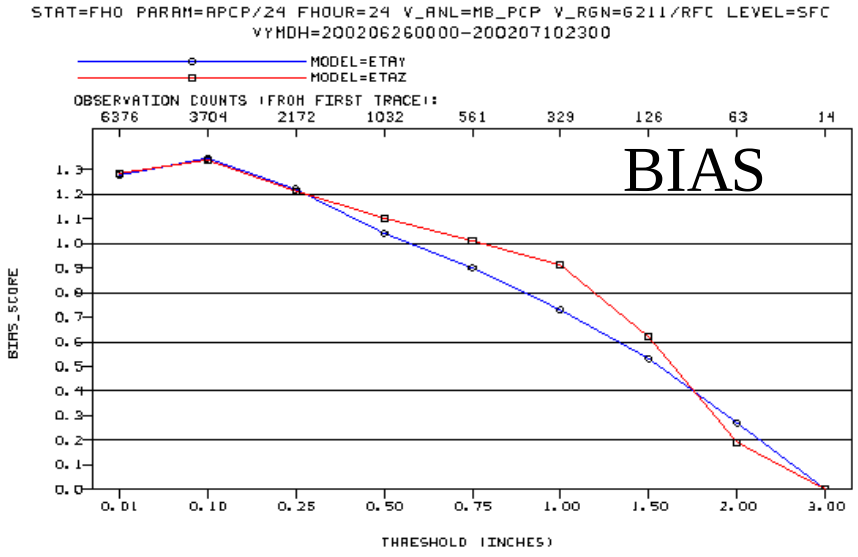
24 hour forecasts

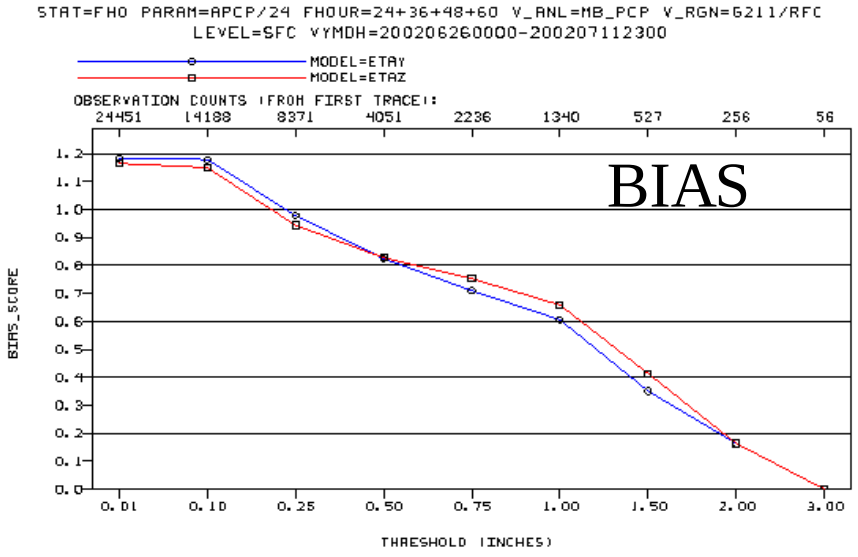
24+36+48+60 hour forecasts

Blue: cloud top assim; Red: Control



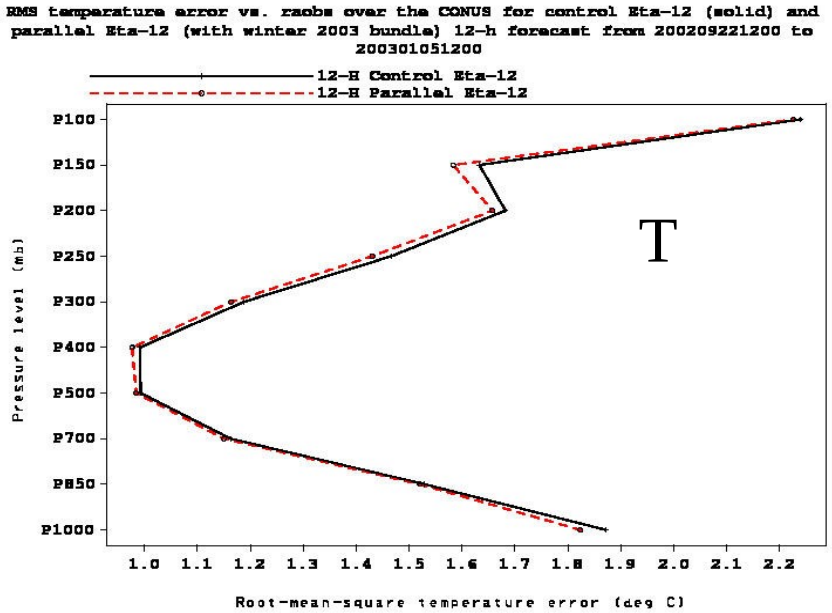


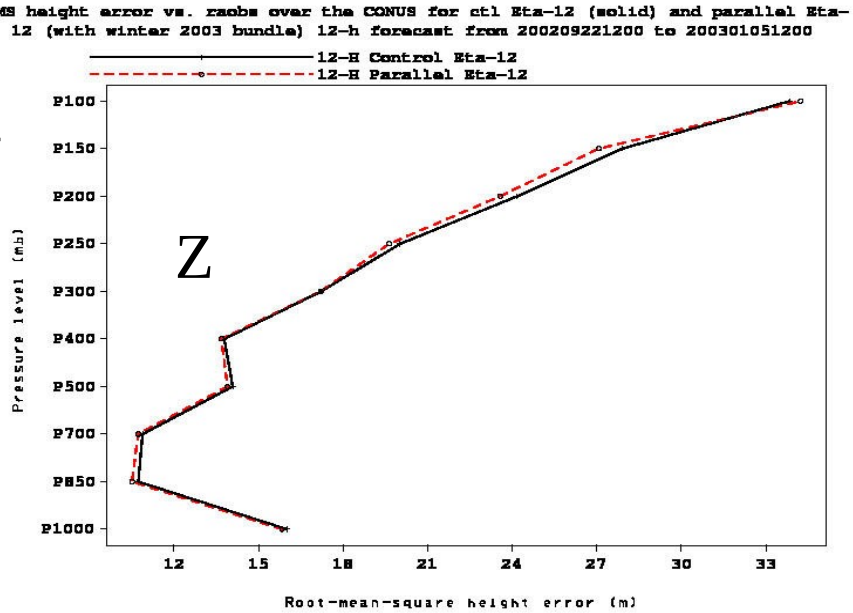


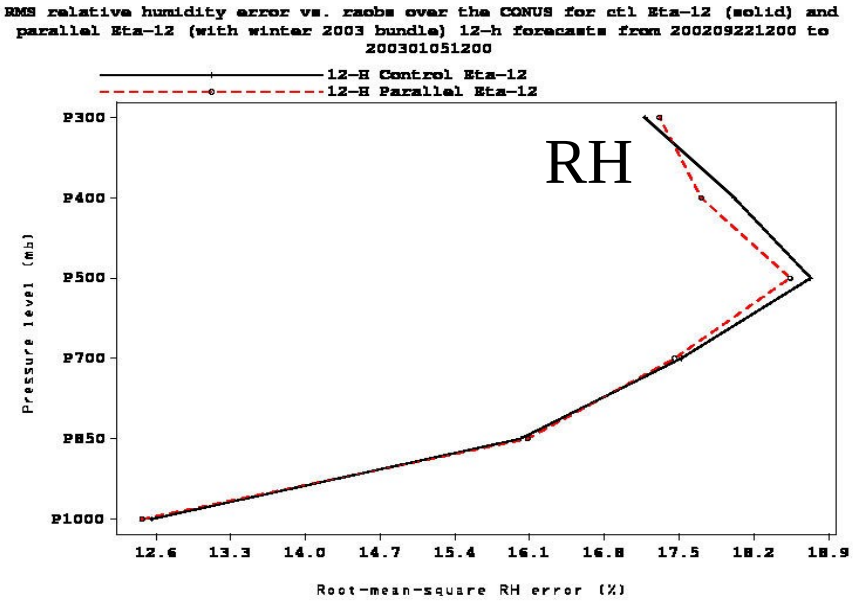


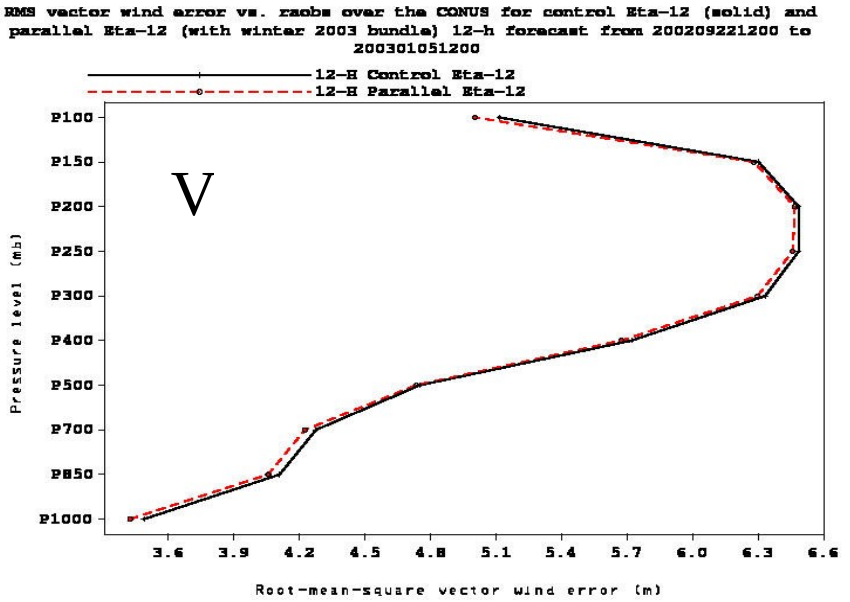
Bundle Verification Results Upper-Air

24 hr

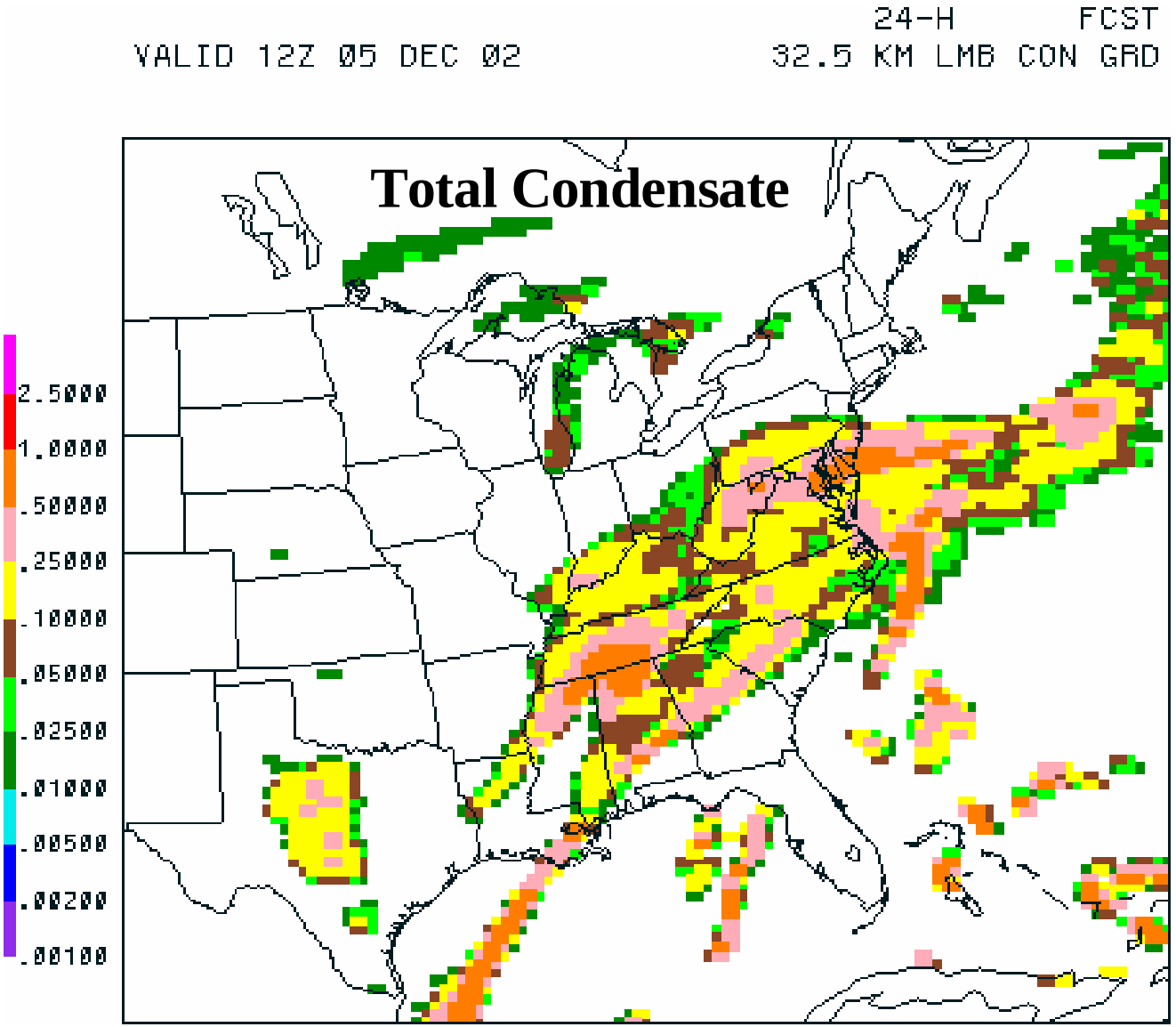




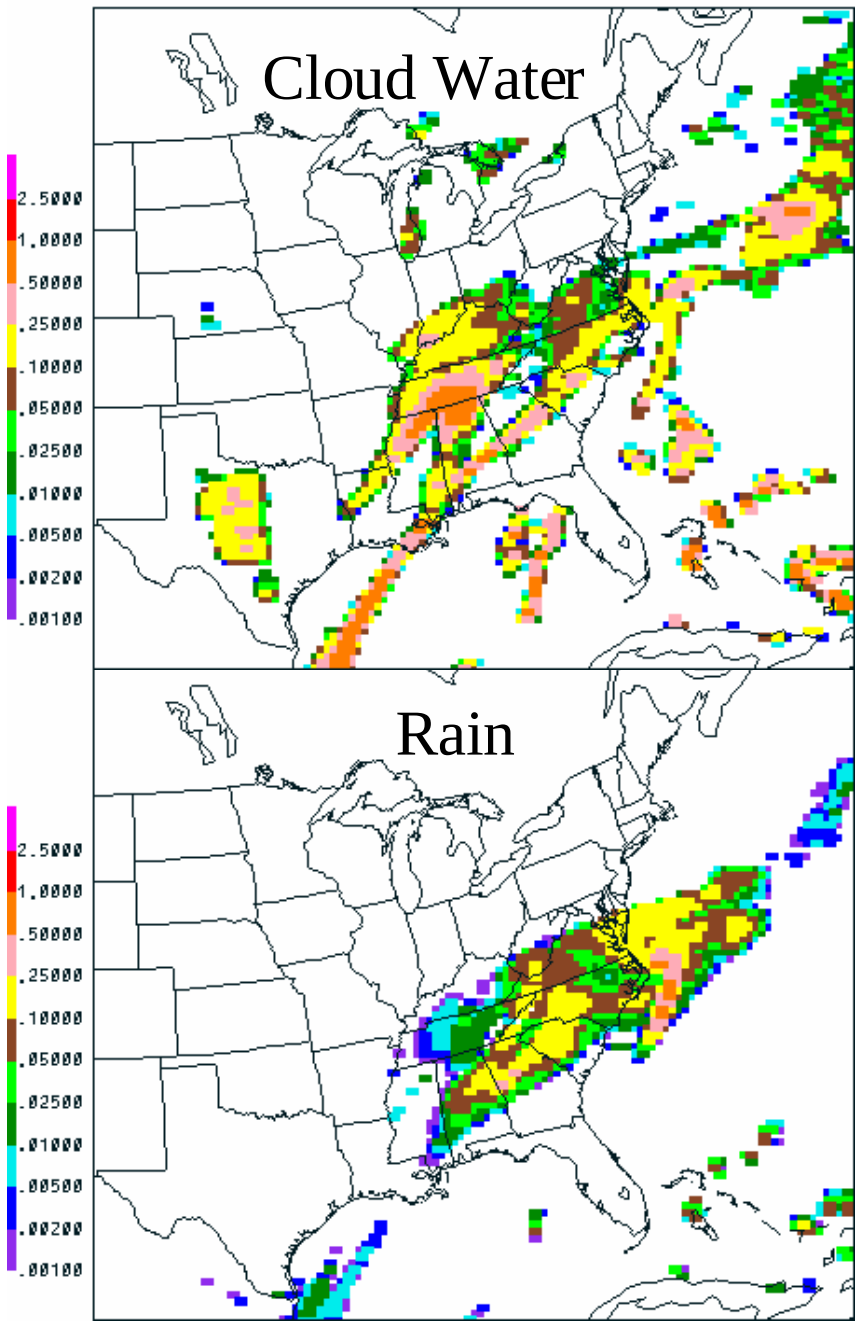


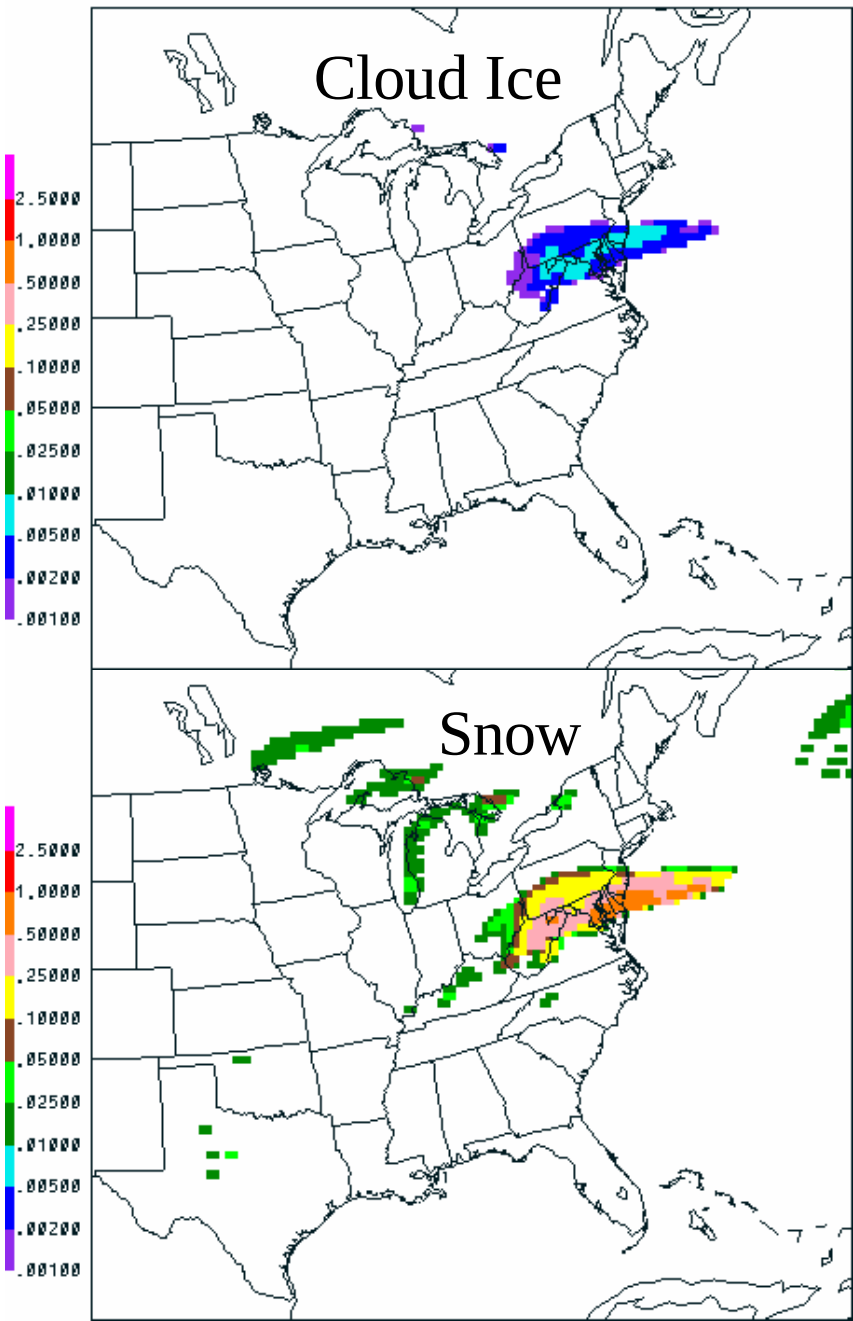


Example of Total Condensate Field From Upgraded Eta Model Post

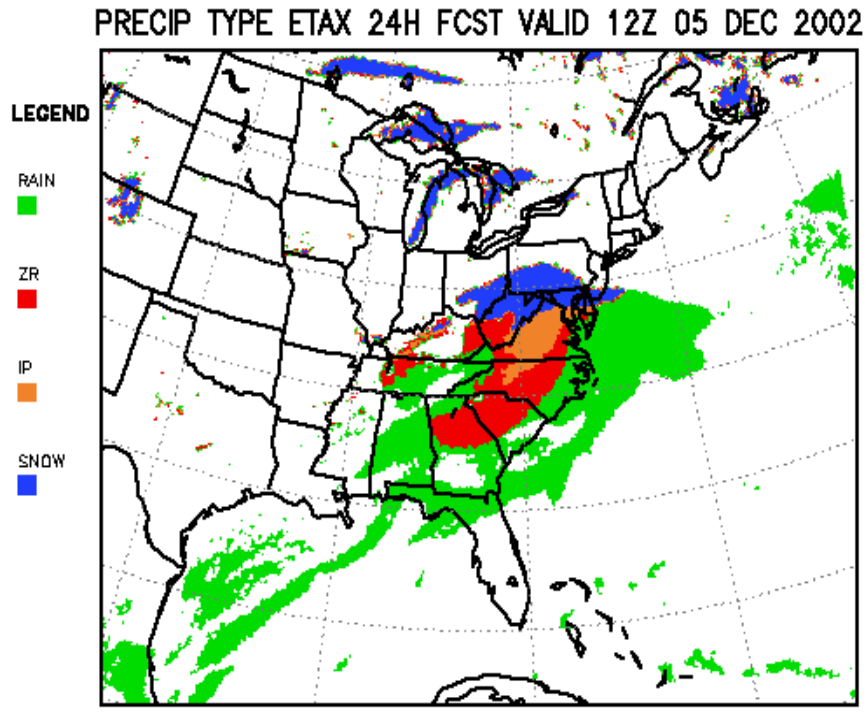


Example of Hydrometeor Fields from Eta

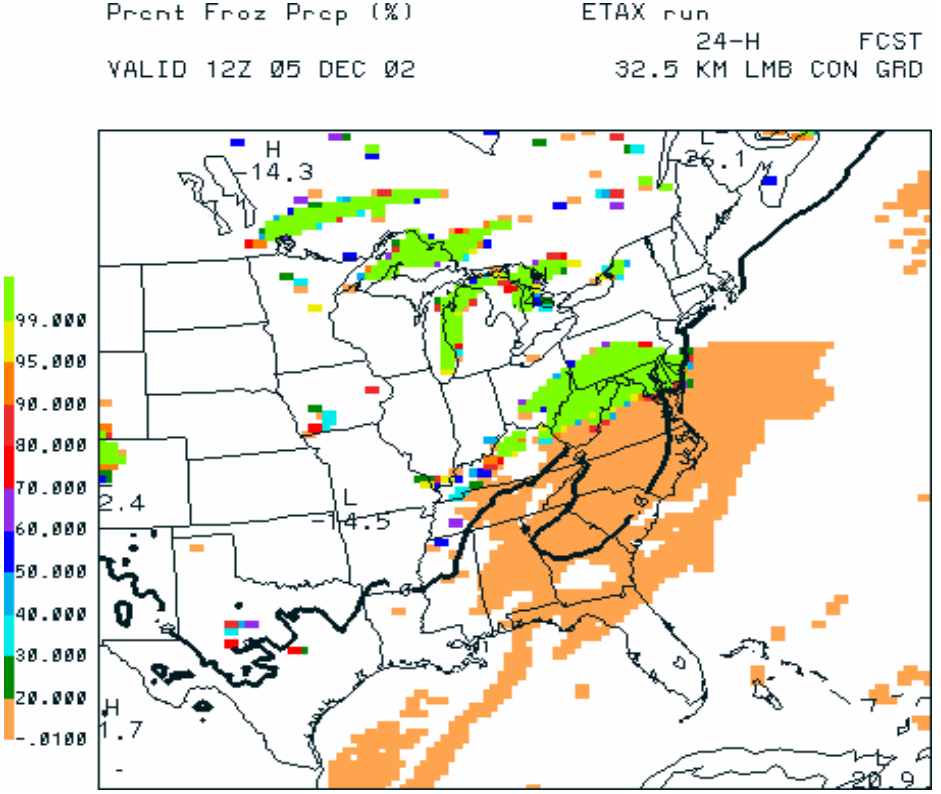




Baldwin Diagnostic Precip Type vs Model Direct Percent Frozen



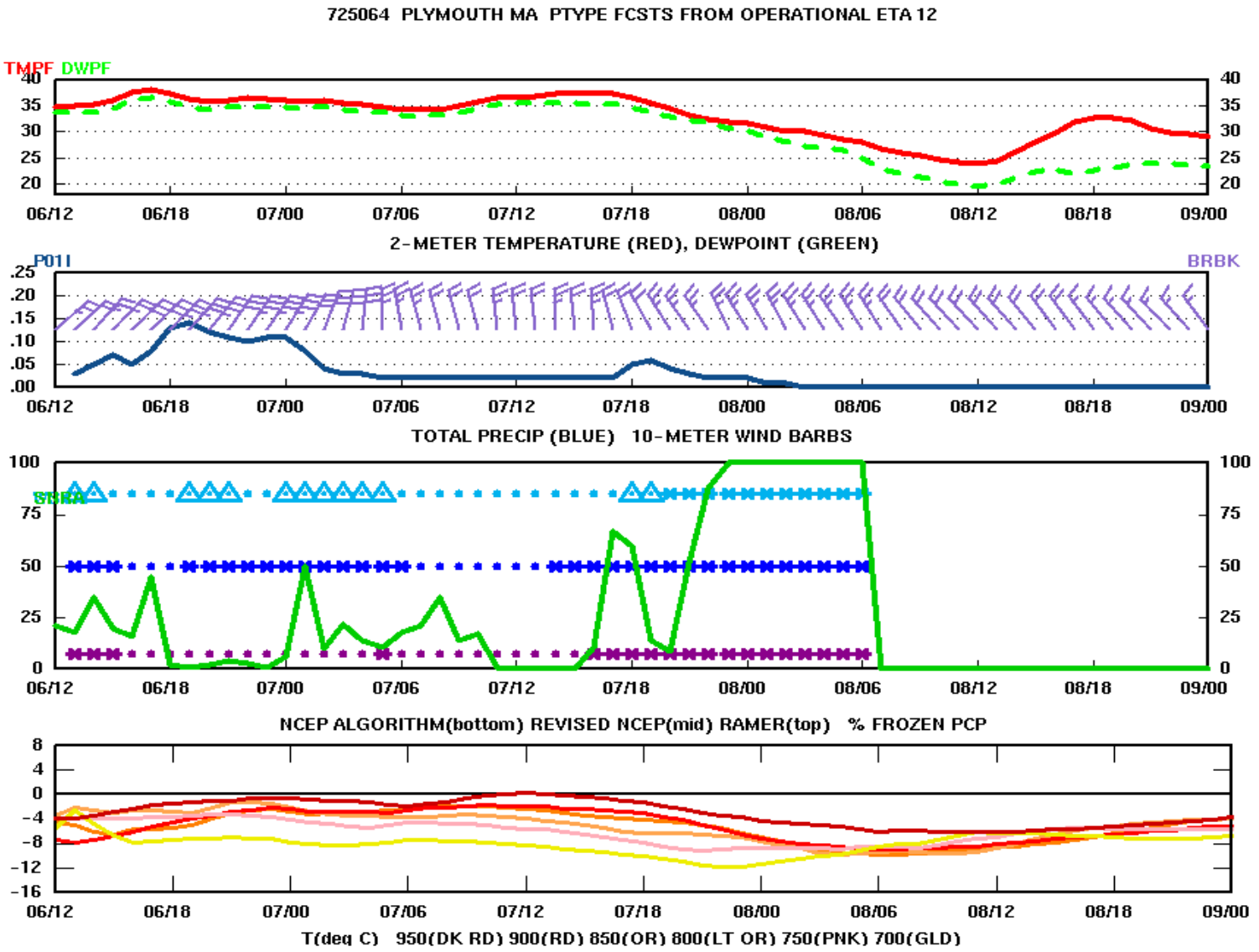
Baldwin Diagnosed Precip Type



Percent Frozen Direct from Model's

Manikin's Precip Type Meteogram Page

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



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.

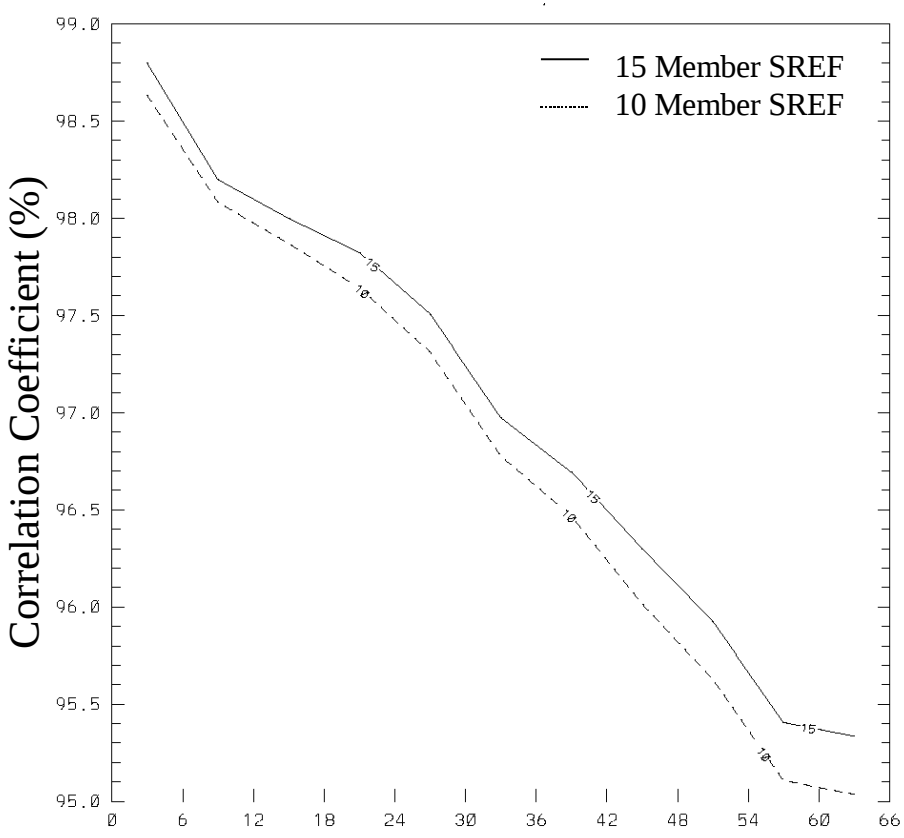
NWS Disclaimer

September Upgrade to Short Range Ensemble Forecast (SREF) System

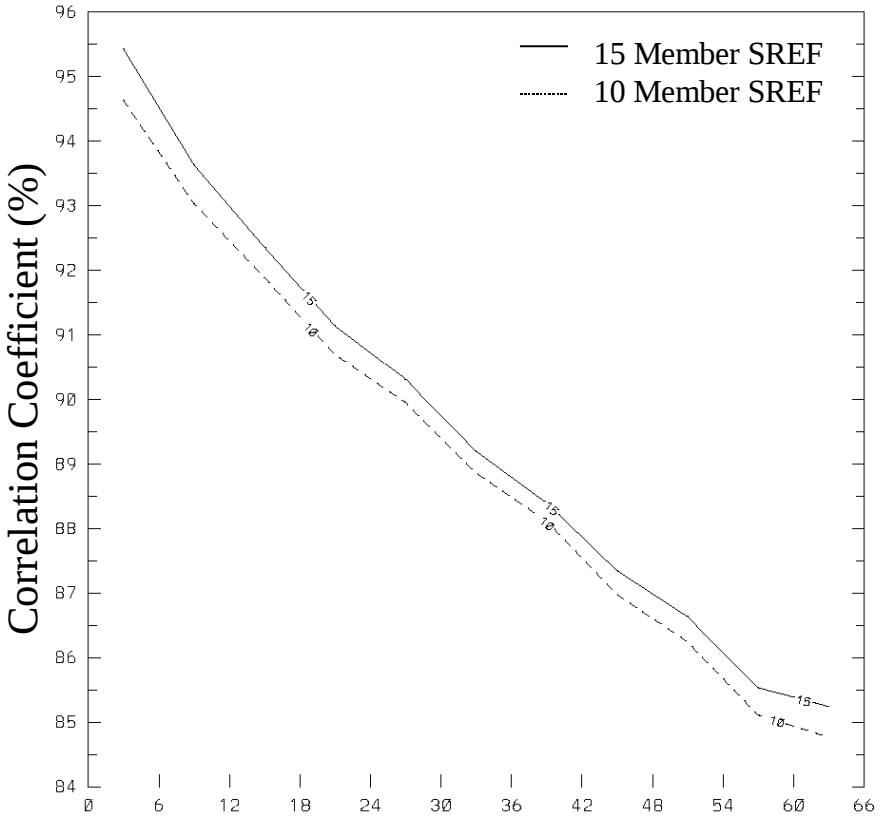
- Added 5 members based on Eta using Kain-Fritsch
- Additional GRIB output:
  - Requested by AWC, SPC, HPC Service Centers
  - Eta: Additional cloud and convective products
  - RSM: Additional convective fields and vertical levels
- Create BUFR Sounding File
  - BUFR Soundings for all 10 Eta ensemble members
  - Requested and used by SPC, HPC and AWC

September SREF Upgrade

July 2003 Correlation Coefficients



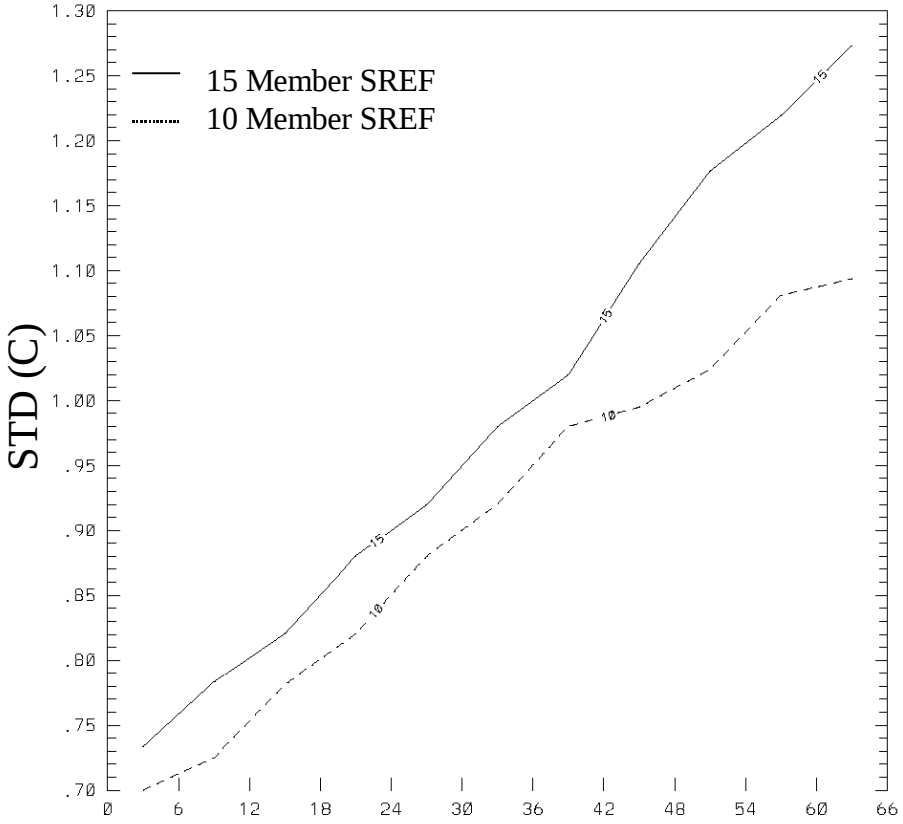
850 mb Temperature



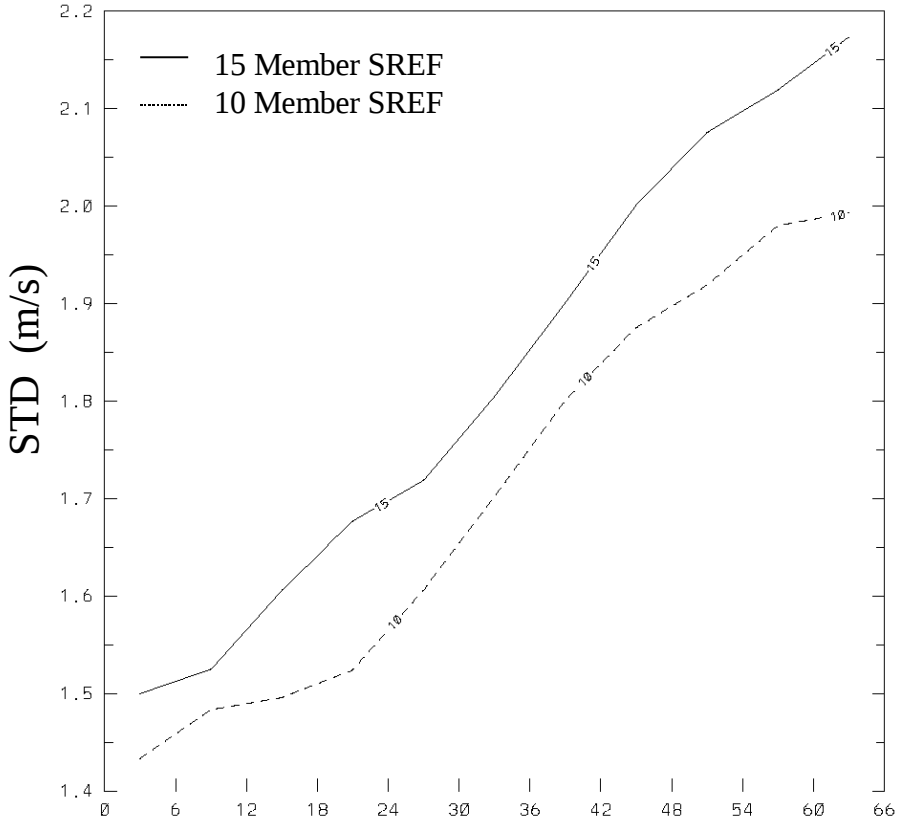
850 mb U-wind

September SREF Upgrade

July 2003 Spread (Std. Deviation)



850 mb Temperature

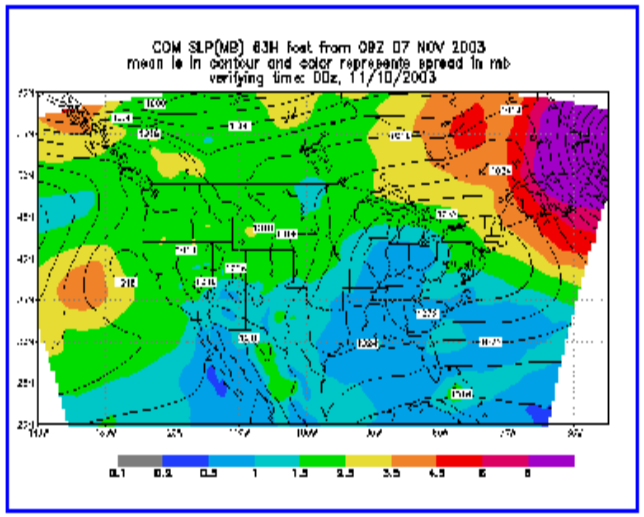


850 mb U-wind

Instant Message

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)
Specific Applications (Aviation, Hydrology, Energy and Fire Weather)

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

PLEASE READ THE DISCLAIMER ON INFORMATION INCLUDED IN THESE WEB DOCUMENTS!

Environmental Modeling Center (EMC)

Transition to				
Today's 21z run				
Past Day's Forecast(under construction)				
SREF Home				
SREF System				
☑ COM 15members	ETA 5members	RSM 5members	KFETA 5members	
Field				
Jet Stream threshold(Knots)		34Kft	18Kft	4.5Kft
		60	80	100
Icing (T & Rh algo)	FL240	FL180	FL150	FL120
	FL090	FL060	FL030	FL000
Tropopause (no RSM)		Height	Temp	
Frz-level (no RSM)		Height		
Cloud total Cloud prob	Mean&spr	Max	Min	
	Clear	Scattered	Broken	Overcast
C&V and Fog (no RSM)	LIFR	☑ IFR	MVFR	VFR
	Visibility	Ceiling	Cloud top	Fog
Convection		Cloud no RSM	Speed &dir	
Turbulence in the Layer (Ellrod algo)	FL420-FL390	FL390-FL360	FL360-FL330	FL330-FL300
	FL300-FL270	FL270-FL240	FL240-FL210	FL210-FL180
Intensity threshold	LGT	MDT	SVR	
Vertical Wind shear		1000-950mb	950-900mb	900-850mb
Max wind		Speed	Hght no RSM	

SREF Aviation webpage

Displays 65 products

For 2 cycles per day (4 in FY04)

At 22 output times (00-63 hr)

Individually or animated loops

5 member combined or

5 member subsets of 3 model configurations:

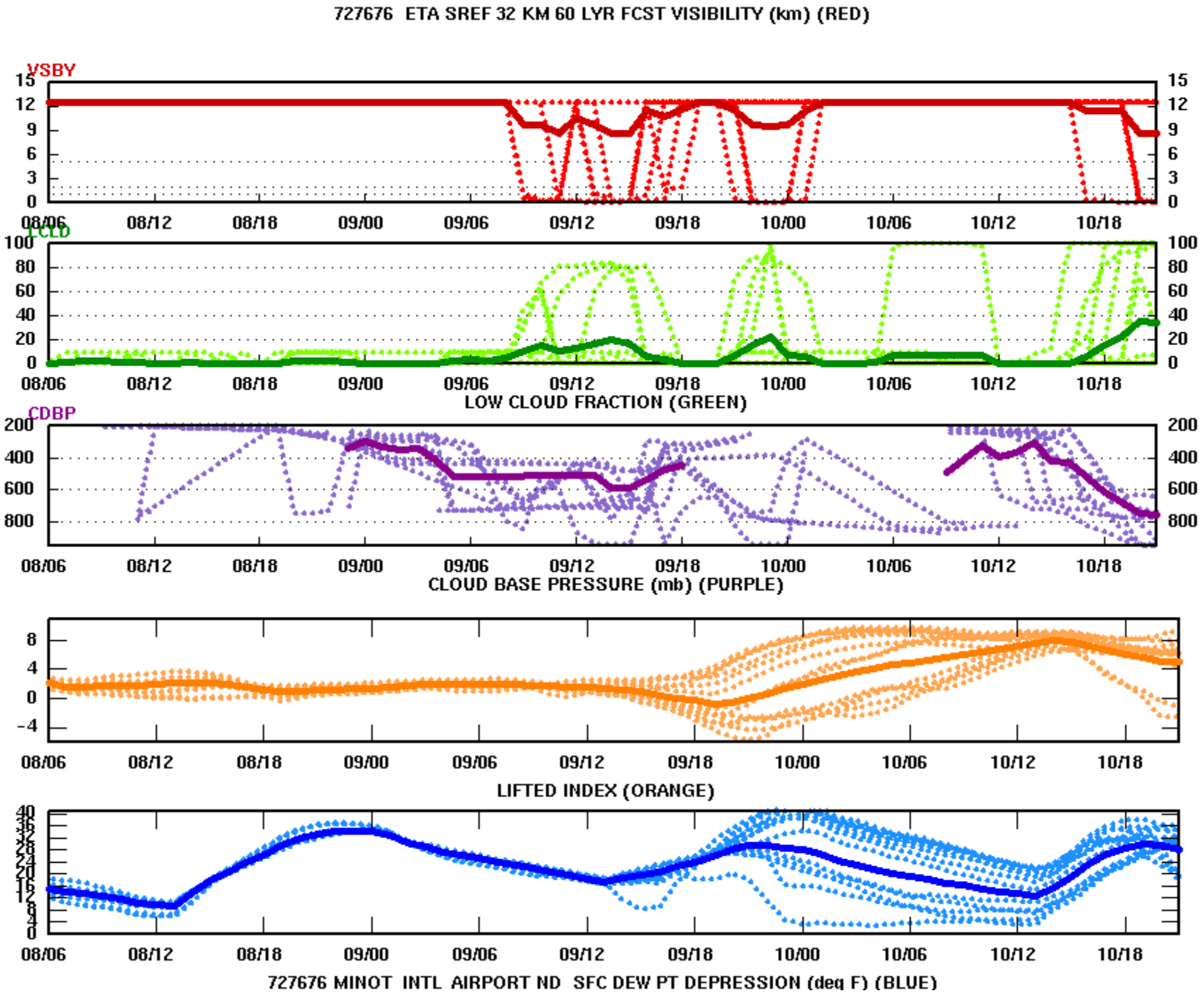
- Eta (using BMJ like opnl)
- Regional Spectral Model
- Eta using Kain-Fritsch

5 member subsets composed of

- Control run and two pairs
- Pairs initialized with +/- bred-mode perturbations

Short Range Ensemble Forecast (SREF) System For January 2004 Implementation

- Combines value of initial condition breeding, physics diversity and improved horizontal resolution
- 3 Meso Eta Model (BMJ) members
- 3 Regional Spectral Model (SAS – new GFS & MPI)
- 2 Meso Eta with Kain-Fritsch members
- 2 Meso Eta with Relaxed Arakawa-Schubert (RAS)
- 2 Regional Spectral Model with RAS
- 2 Meso Eta with Kain-Fritsch Full Detrainment
- 1 Meso Eta with Ferrier Modified Shallow Convection
- BUFR soundings from RSM members as well as Eta
- Domain is full North American continent
- Resolution is 32/35 km versus 48 km


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
FCLD
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)
727676 MINOT INTL AIRPORT ND SFC DEW PT DEPRESSION (deg F) (BLUE)

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

National Air Quality Forecasting

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
- Program has purchased additional computer power to perform AQF and promised this increment for perpetuity

National Air Quality Forecasting

Initial Operational System

Linked numerical prediction system

- NCEP Eta-12 mesoscale model for meteorology & its evolution
- EPA community multi-scale air quality model (CMAQ) for ozone & eventually PM
  - Consistent model structures for interaction of urban thru continental scales
- AQ Observational Input:
  - 1999 EPA emissions inventory
  - Meteor. Dependent biogenic emissions
  - Climatological averaged mobile sources

Gridded forecast guidance products

- NCEP delivers ozone grids to NWS TOC / Communications Gateway
- EPA picks up and passes to State agencies
- State agencies issue official forecast

Verification basis

- EPA ground-level ozone observations

Customer outreach/feedback

- State and Local AQ forecasters coordinated with EPA
- Public and Private Sector AQ constituents

Air Quality Prediction System

Components

- Eta-CMAQ Post:
  - Interpolate from eta to 22 CMAQ sigma levels
  - Additional fields for AQ (pbl height, canopy cond., etc)
- Eta Product Generator: Interpolate to CMAQ C grid
- PREMAQ: Process static & met dependent emissions

Volatile Organic Compounds (VOCs)	Nitric oxides (Nox)
Biogenic (>50% of emissions): Strong met. dependence (T, PAR)	Major fossil-fuel power plants (~35%) t dep & maint sched
Mobile (~25% of inventory) Large diurnal & day-of-week variations	Mobile (~30%) temp & wind dependence
Evaporative Emission ~ temperature	Soil (~10%) temp & soil moisture dependence
Other anthropogenic - assume no diurnal met influence	Other anthropogenic (25%) – Lightning - not modeled

- CMAQ: Community Multi-scale Air Quality Model
- CMAQ Product Generator: Output sfc ozone in Grib

AQF Specifications

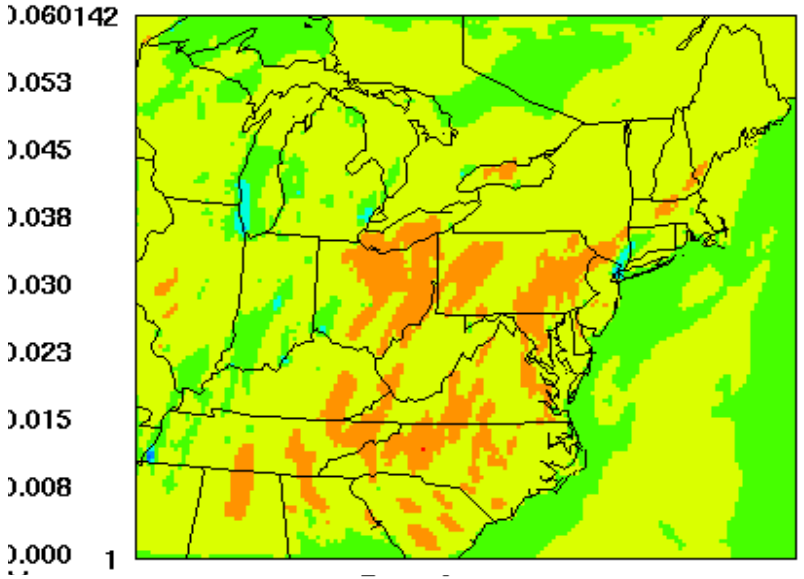
- Development Test & Evaluation was run in 2003
- Operational Test & Evaluation to be run in 2004
- IOC Northeastern US Domain :
  - 166x142 Lambert-ConformalArakawa C grid
  - 12 km grid spacing
  - 22 sigma-P levels to 100 mb
  - 35 minutes for a 48 hour forecast (33 tasks)
- Initial Conditions:: CMAQ forecast with new Eta forecast every 6 hours
- Boundary Conditions : Constant
- Data Assimilation: None

CMAQ Capabilities

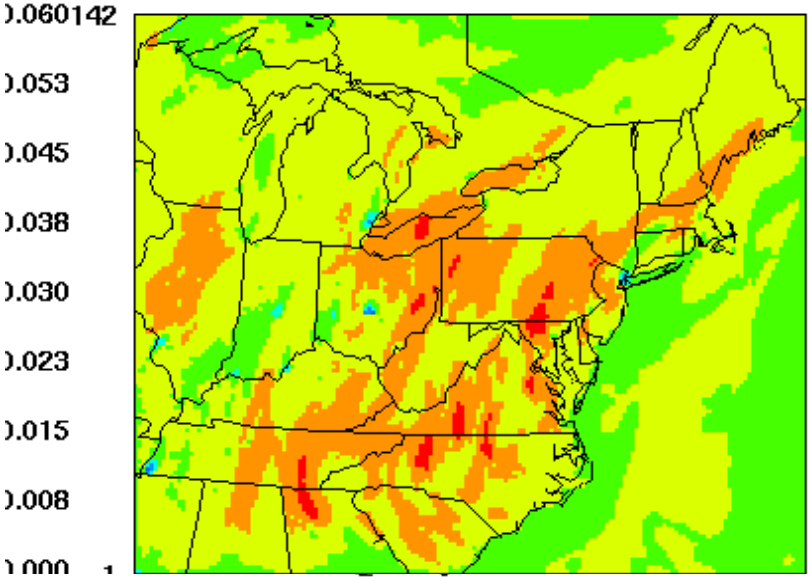
- Chemical Transport Mechanism
  - Advection: Piecewise Parabolic method (PPM)
  - Vertical Diffusion: Asymmetric Convective Model (ACM)
  - Horizontal Diffusion: Eddy-diffusivity with Kh grid size dependent
- Cloud processes: Aqueous chemistry & sub-grid clouds from RADM: OFF
- Plume-in-Grid: Subgrid Lagrangian plume effects: OFF
- Dry Deposition: M3dry: deposition velocities computed from the Pliem-Xu LSM
- Gas-Phase Chemistry Mechanisms:
  - Smaller Carbon Bond 4 (CB4), limited species - Use Chemical steady states
- Gas-phase Chemistry Solver: Fast Henkel solver
- Aerosols:
  - Inorganic, 2nd anthropogenic & Speciated primary emissions (Carbon, sulfate, nitrates) OFF
- Particulates, Visibility, Acid Deposition & Air Toxics OFF

Retrospective Test Results:Predicted Surface Ozone Concentrations

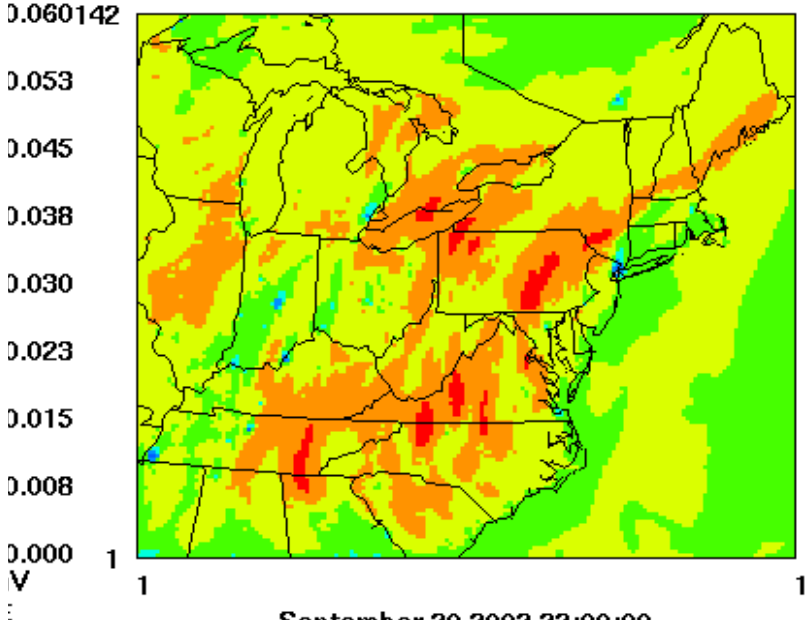
September 20, 20002 – 14:00 EDT



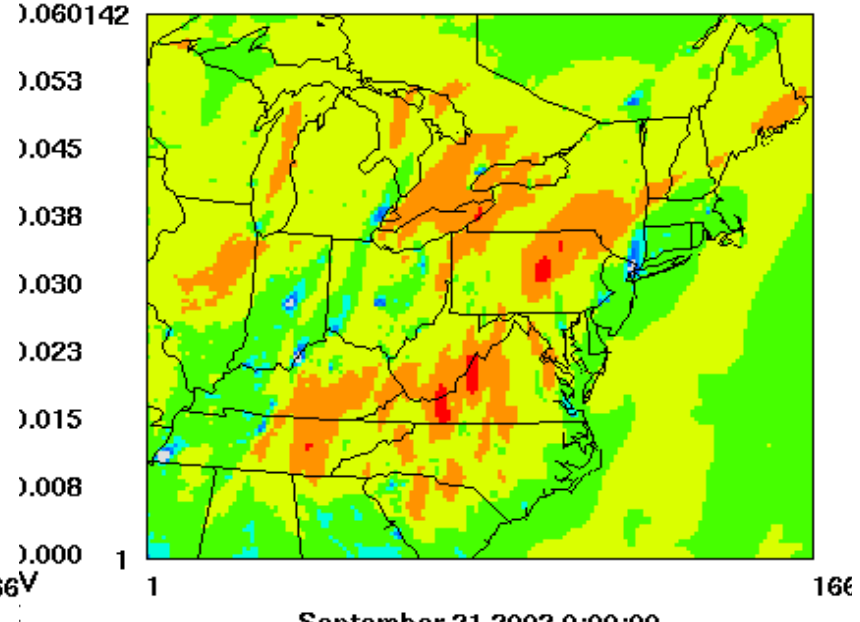
September 20, 20002 – 16:00 EDT



September 20, 20002 – 18:00 EDT



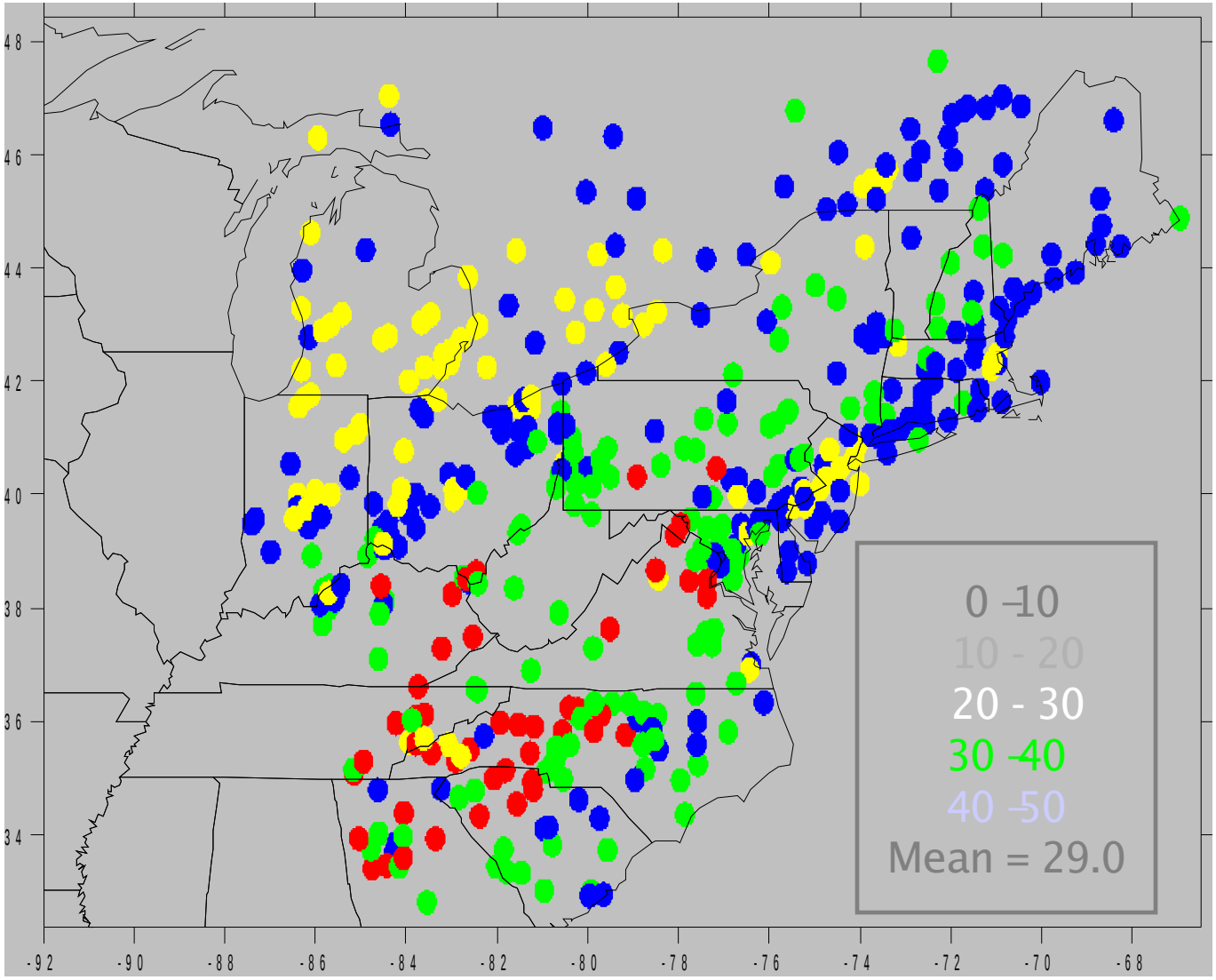
September 20, 20002 – 20:00 EDT



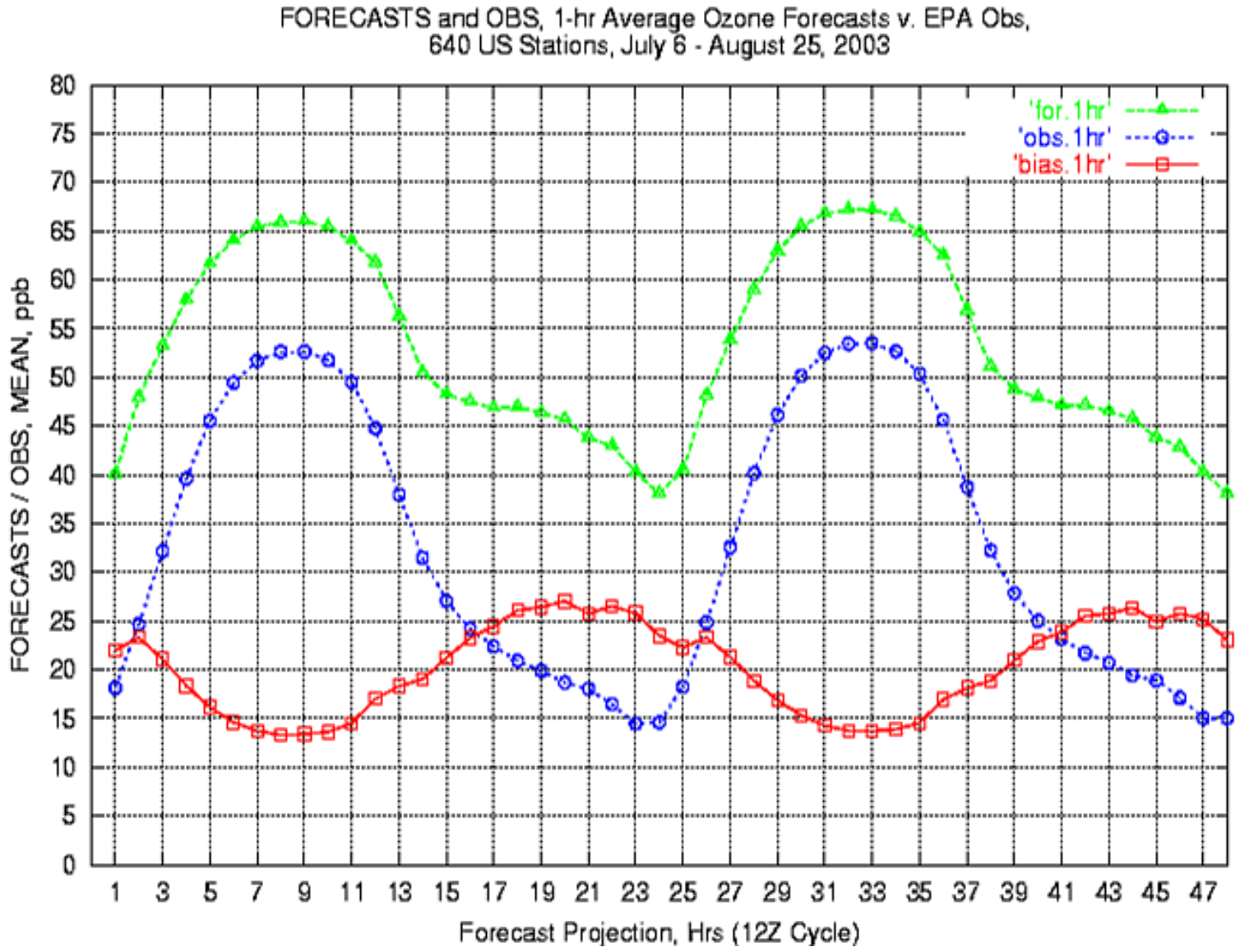
DT&E Spatial Evaluation vs Obs

Hourly O_3

Root Mean Square Error



CMAQ(green), Obs(blue),Bias(red) after land-use correction



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

Regional Reanalysis System Design

- Fully cycled 3-hr EDAS
- Lateral boundary conditions supplied by Global Reanalysis 2 (GR2)
- Free forecasts made out to 72 hr every 2.5 days, using GR2 forecast boundary conditions
- Pilot Test resolution 80-km, 38 layers
- Production resolution: 32-km, 45 layers
- Domain covers North American continent
- RR time period: 1979-2003 (continued later in near-real time, as in CDAS)

Data Used in Global Reanalysis and Regional Reanalysis

Dataset	Details	Source
Radiosondes	Temperature, winds, moisture	NCEP/NCAR Global Reanalysis (GR)
Dropsondes	Same as above	GR
Pibals	Wind	GR
Aircraft	Temp. and wind	GR
Surface	Pressure	GR
Cloud drift winds	Geostationary satellite	GR

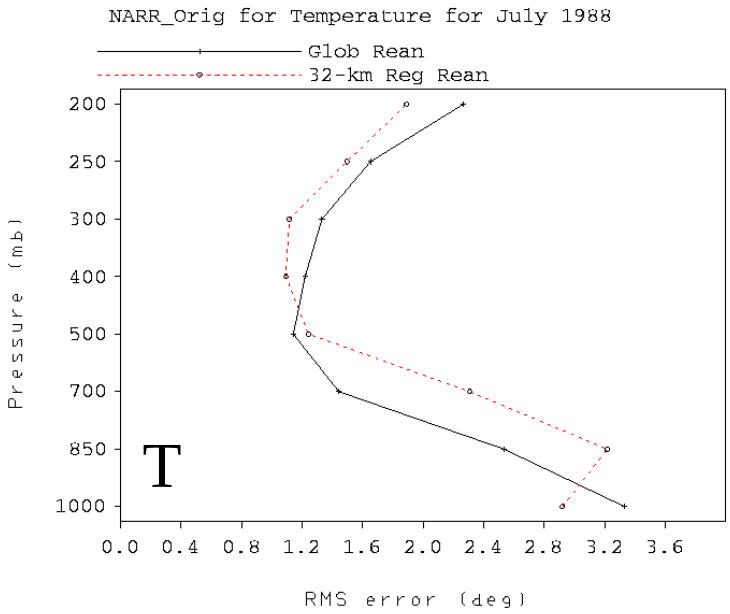
Data Added or Improved Upon for Regional Reanalysis

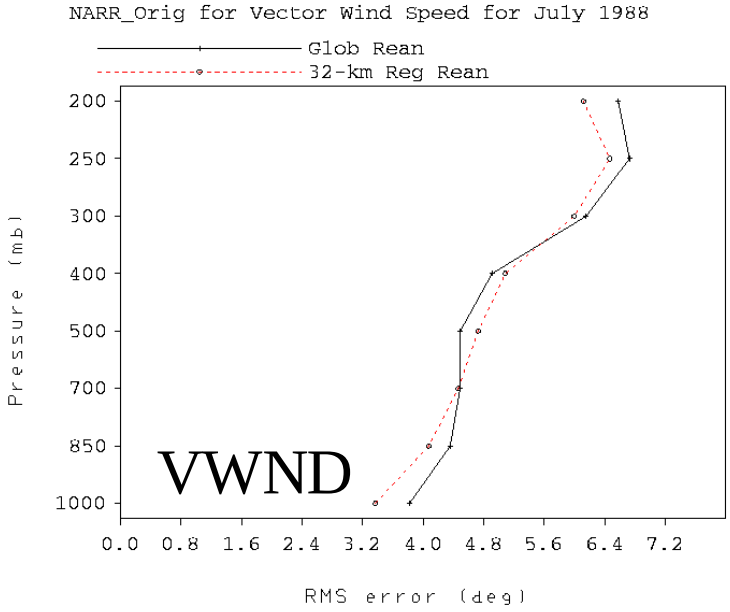
Dataset	Details	Source
Precipitation	CONUS (with PRISM), Mexico, Canada, CMAP over oceans	NCEP/CPC
TOVS-1B radiances	Winds, precipitable water over oceans	NESDIS
Surface	Temperature, wind, moisture	GR
TDL Surface	Pres, temp, wind, moisture	NCAR
COADS	Ship and buoy data	NCEP/EMC
Air Force Snow	Snow depth	COLA and NCEP/EMC
SST	1-degree Reynolds, with Great Lakes SSTs	NCEP/EMC, GLERL
Sea and lake ice	Contains data on Canadian lakes, Great Lakes	NCEP/EMC, GLERL, Canadian Ice Center
Tropical cyclones	Locations used for blocking of CMAP Precipitation	Lawrence Livermore National Laboratory

Surface Data Assimilation

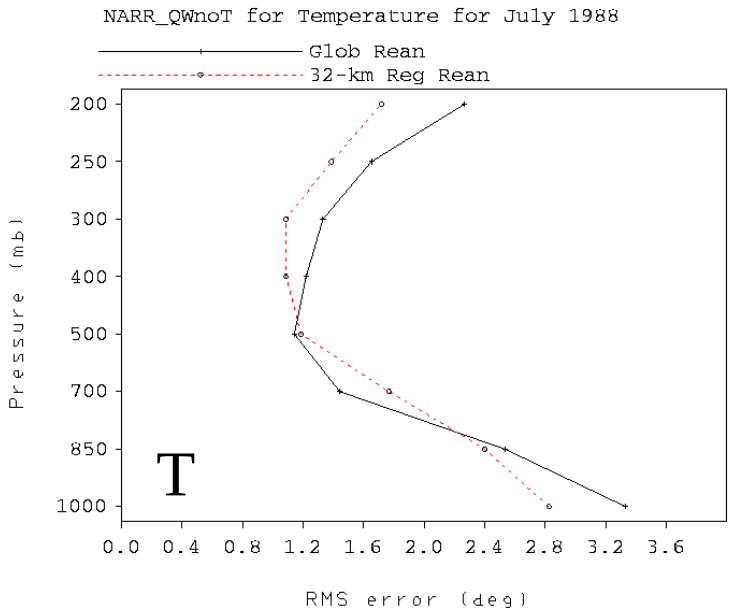
- Reduction of time-window for sfc obs in 3DVAR
  - Reduces noise, improves analysis and 3-hr first guess
- Exclude 2-m land surface station air temperatures:
  - Harm the analysis so that first guess is worse
  - Increases upper-air errors: T at 850- and 700-mb, winds at mid- and upper troposphere (!)
  - Removal from analysis decreases errors
- Led to turning off these same data in operational Eta 3DVAR 10 September 2003

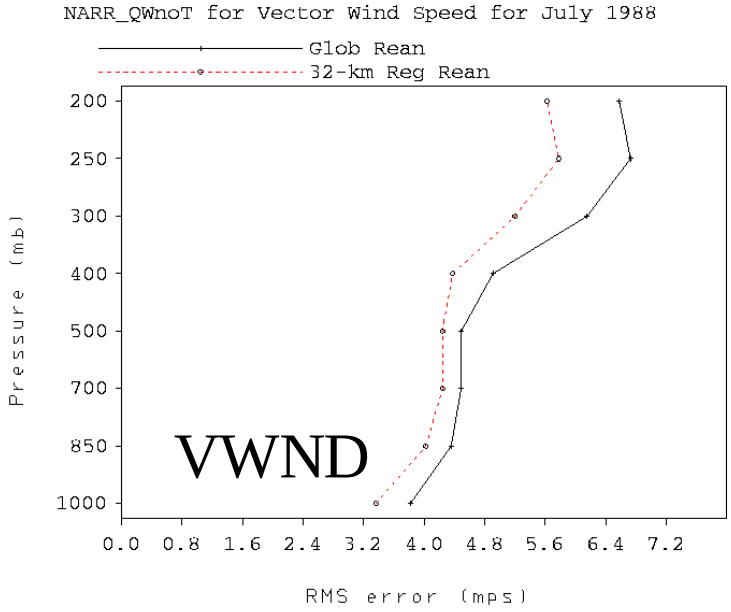
Full Assimilation



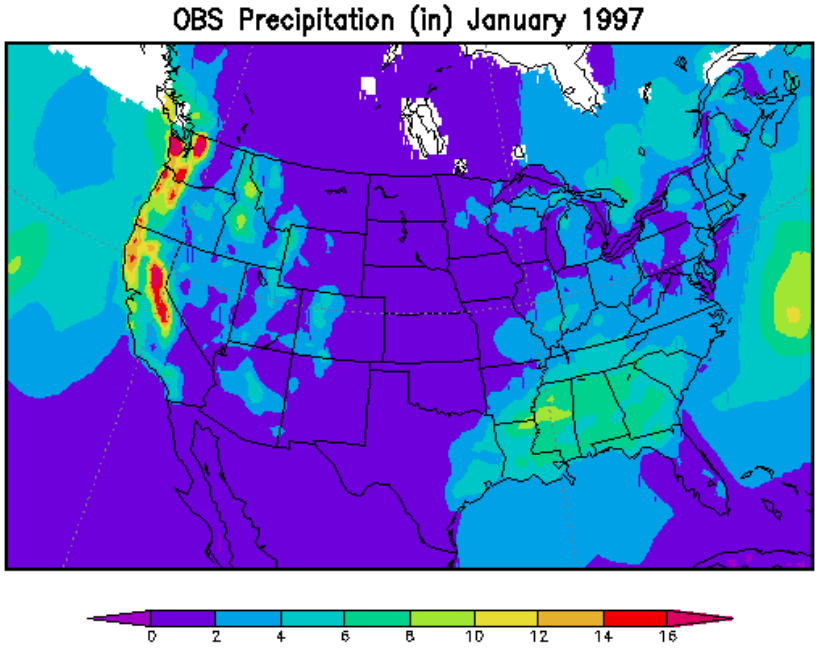


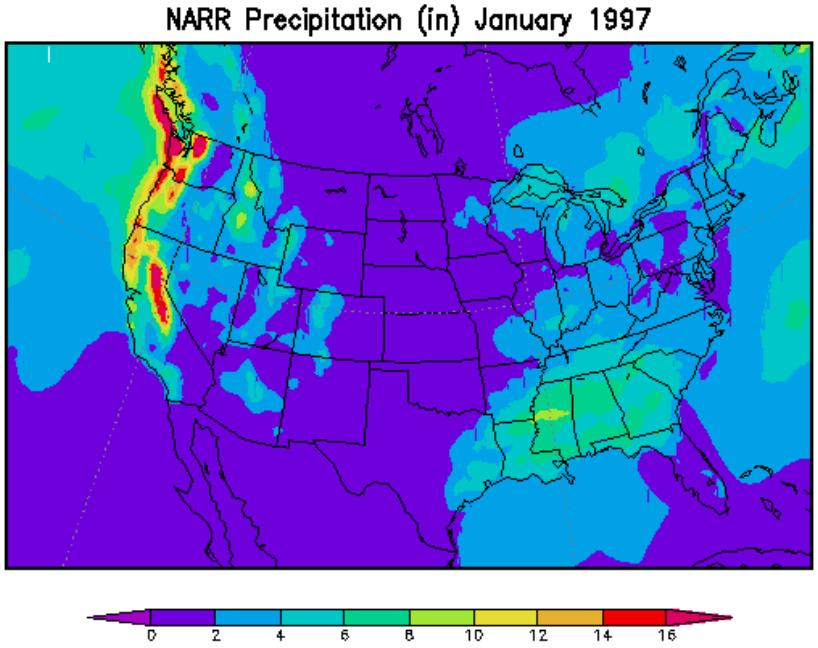
No 2-m T anal.





January 1997 Precipitation Results





Unique RR Achievement

- Completed 24 years of RR production in just over 3 months, running 4 simultaneous streams, on old NCEP Production half of IBM Class-VIII

Work in Progress

- Getting data subsets to distribution centers
  - National Climatic Data Center
  - National Centers for Atmospheric Research
  - San Diego Supercomputing Center
  - University of Maryland
- Preparing DVD for AMS Bulletin article
- Preparing R-CDAS for perpetual running of RR system by NCEP's CPC

N
C
E
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NCEP Proposal for: Downscaling Model Grids for NDFD Out To 8 Days

Geoff DiMego

21 October 2003

where the nation's climate and weather services begin

OUTLINE

- Purpose of Downscaling
- Chronology
- Relevance to NDFD
- Extension to Day 8
  - Background
  - Feasibility
  - Proposal
- Product Generation & Distribution
- Exit Strategy
- Steps for Implementation
- NCEP Concerns

Purpose of Downscaling

- Extend the information content of coarse model prediction fields to finer scales that reflect the influence of detailed local effects such as terrain and or land-surface
- Initialization of NDFD especially at day 8
- Analysis of Record needed to verify NDFD

CHRONOLOGY

- Request from Glahn & Livesey for Analysis of Record to verify NDFD (unofficial & unfunded)
- Request from Jack Hayes/Brad Colman for 1-page proposals for downscaling approaches:
  - 25 year 2 km climo of sensible wx by downscaling 25 year 32 km NARR used as observed basis for MOS/Neural Net development to downscale NARR & GR forecasts to 2 km
  - Local model with nudging
  - Anomaly techniques (Lord & Toth)
- First approach (preferred) had long timeline (2+ yrs)
- Brad Colman came to EMC based on strong desire for something to help forecasters with NDFD in the short term -- led to idea to downscale GFS guidance using reduced domain Eta extension to 8 days

Relevance to NDFD

- Immediate need of the NWS Field is for high res grids to initialize GFE/IFPS/NDFD especially at day 8:
- High resolution grids of at least 5 km with a preference for 2.5 km
- Grids with uniform content out to day 8 at least once per day (currently using MRF grids which will be replaced by 4/day GFS so demand may be for more than just once per day)
- NDFD parameters (sensible weather) but preferably full 3-D grids to populate GFE / IFPS in anticipation of improving SMART TOOLS

Extension to 8 Days: Background

- Original discussion with Brad called for a single 24 hour Eta-12 forecast cold-started from 6.5 or 7 day GFS forecast (would have major spin-up problems)
- EMC countered with extension from 60 hr for small ($1/6^{th}$) domain and run instead of 06z extension
- NCEP Director pushback eliminated option to run instead of 06z extension
- EMC adjusted plan to push current 60 hr primary run from 60 hr to 84 hr with computer upgrade
- Colman pushback eliminated option to wait until after computer upgrade (06/04)

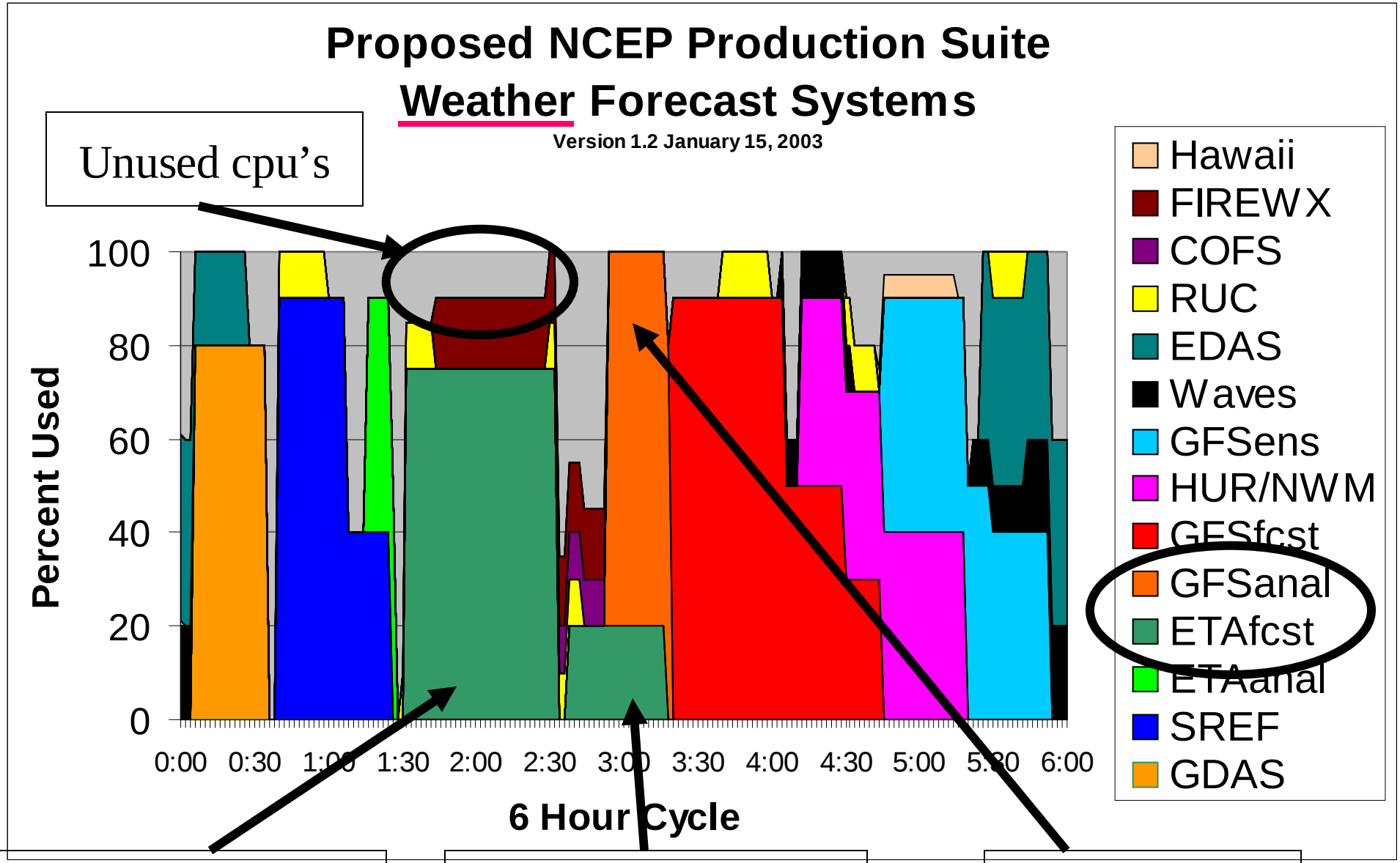
Extension to 8 Days: Feasibility

- Eta extension will produce the desired effect of downscaling the GFS solution because the GFS synoptic scale forecast will dominate the Eta solution in the interior through the effects of the lateral boundary conditions especially for this small a domain and for this long of a prediction
- EMC/CPC have run Eta for extended periods before with no ill effects (but on larger domain)
  - 10+ days with MRF forecast lateral boundaries
  - 90+ days with Global Reanalysis lateral boundaries

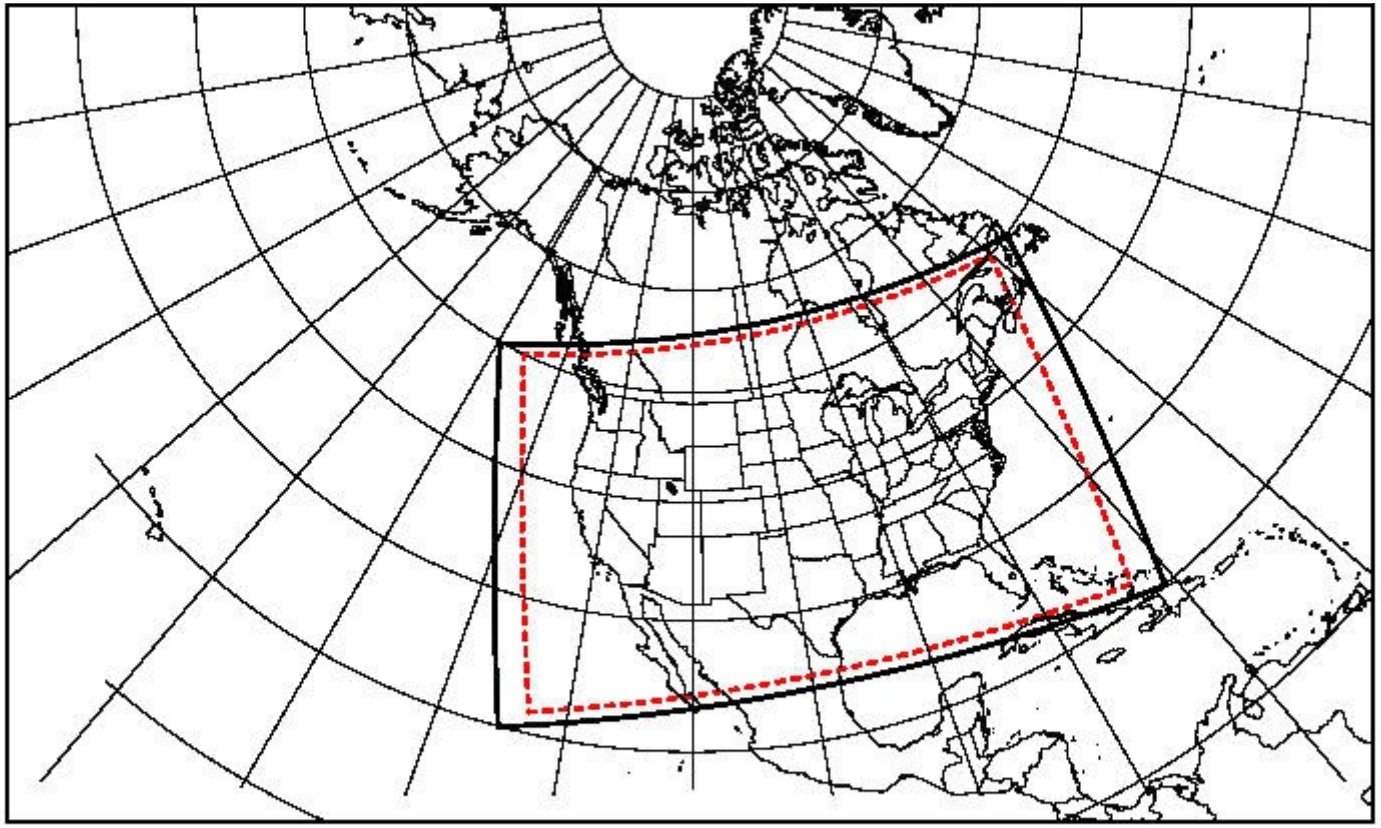
Extension to 8 Days: Proposal

- Currently run Eta-12 in 2 pieces:
  - Large block of machine to make 0-60 hr fcst
  - Small block of machine to make 60-84 hr extension
- Proposal is to:
  - Make first block bigger to make 84 hr fcst in same time window as 60 hr is taking now (NCO has verified availability of sufficient processors to do this)
  - Use small block (no change in cpu resource) to run 4.5 day (84-192 hr) extension for small domain (1/4.5=2/9th)
- Initially, can run CONUS domain (2/9th) at 06z &18z
- Subsequently, might also run OCONUS domains for AK (1/7th), HI (1/25th) & PR (1/25th) at 00z &12z

Wx Production Suite Made Up of Four Uniform Cycles per Day



Reduced Eta Domains Which Would Allow 5 or 6 Day Extension in Same Slot as Current 1 Day Extension on Full Domain



Domain could be slightly larger since we only need to extend 4.5 days so we only need to reduce domain to 2/9th

Product Generation/Distribution

- Regional subsets of 12 km Eta grids made available to Regional Offices from TOC server via WAN or dark fiber
- *Regions download, convert to NeTCDF and distribute to their WFO's using LAN's & LDM
- *WFO Downscales 12 km Eta grids using national form of SMART INIT (Tim Barker)
- Eventually, downscale 12 km Eta grids centrally
  - Take advantage of full 3-D Eta-12 grids available centrally
  - Produce much smaller volume of 5 km NDFD parameter grids (GRIB2) which are 2-D sensible weather fields

*Can't be decided by NCEP – must be worked from NWS/HQ & CIO & Regions

NCO is concerned about overloading comm's & TOC processing capability

NCEP is concerned about getting locked into doing this extension forever

Steps to Implementation

- NCO to validate strategy in general and verify availability of processors in particular - done
- Precise definition of products (almost done)
- Precise definition of product form (GRIB or GRIB2)
- Resolve exact distribution / comm's path all the way into AWIPA/GFE/IFPS so NDFD benefits
- Assurance that MIC's in all regions embrace this strategy and the field forecasters can use the resulting guidance grids

Analysis of Record (AoR)

- Forecasters want one (in near real-time)
- NWS/HQ wants one to verify NDFD
- Glahn & Livesey expressed desire for a centrally generated AoR in October 2002 but said there were no resources available
- This and other possible uses / requirements (e.g. Surface Transportation and Local Modeling etc) were enough justification to start thinking

EMC's AoR Concept

- Can't just apply simple 2-d analysis to surface data - even though we have tens of thousands of mesonet obs, we have millions of grid-points
- Need a 3-d forecast model to obtain proper solution dictated among observed data, terrain & lower boundary forcing and synoptic forcing
- Propose to apply tried & true NCEP 4-dimensional data assimilation technique of forecast-analysis cycle at high resolution (2 km) with cost cutting measures to make feasible in production

EMC's AoR Concept

- NCEP's 4DDA (EDAS) uses full complexity of NOAH Land-Surface Model and assimilation of precipitation data to ensure lower-boundary states are optimal
- Use WRF-NMM as assimilating model to include nonhydrostatic effects in terrain following coordinate
- Nudge prediction in free atmosphere to existing solution provided by operational Eta-12 (NAM-WRF)
  - Allows focus of 3DVAR on surface where we have majority of truly mesoscale observations
  - Allows use of coarser resolution in vertical (20 vs 60 levels)
- 3DVAR can be (is being) tuned to be primarily 2-dimensional with anisotropic covariance structures that follow the terrain and depend on atmospheric flow

EMC's Downscaling Concept

- Apply EMC's AoR concept to 25-year North American Regional Reanalysis (2-2.5 FTE+CPU)
- Produce 25 years of 2 km sensible weather grids
- Use with NARR & GR free forecasts to produce MOS/NN coefficients for use with NCEP model guidance to produce downscaled results for every gridpoint at every WFO (? FTE – primarily MDL)
  - Produce just NDFD variables (sensible weather)
  - Produce 3-d variables for high res input to SMART INIT to allow forecaster to add value via GFE and IFPS in producing the actual NDFD fields

Where (or Whether) to Downscale NARR and Perform AoR

- Need substantial computer power to produce 2 km downscaled NARR even if done just every 3 hours – might have to settle for 5 km
- Near real-time AoR would take ~15% of current machine 24 hours a day to do hourly AoR at 2 km with 6 hour delay (to get precip)
- EMC needs direction and resources if either of these are to pursued. Regions might want to push through their RDs.

Eta Upgrade Package Targeted for January 2004 Implementation

- Parallel testing with both 32-km and 12-km EDAS/Eta parallel systems is ongoing
- Upgrades being tested include:
  - Upgrade of NOAH Land-Surface Model from version 2.3.2 to version 2.7
  - Adjustment of biases in the multi-sensor precipitation analyses using daily gauge data
  - Upgrades to the Eta 3DVAR analysis
    - Include use of GOES-12 radiances
    - Better code with vastly improved memory use

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
- change 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

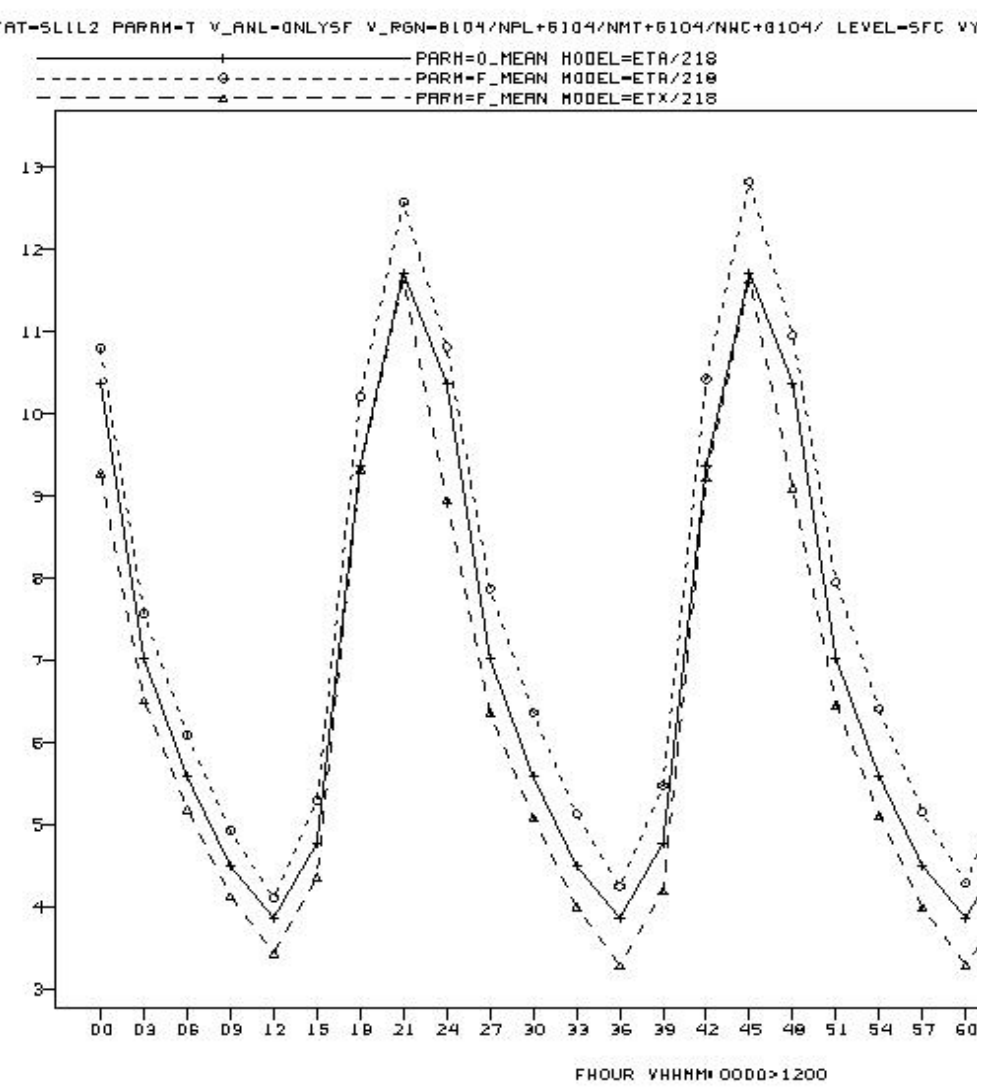
- pass fraction of frozen precip from Eta microphysics to land-sfc module

5 -- Miscellaneous

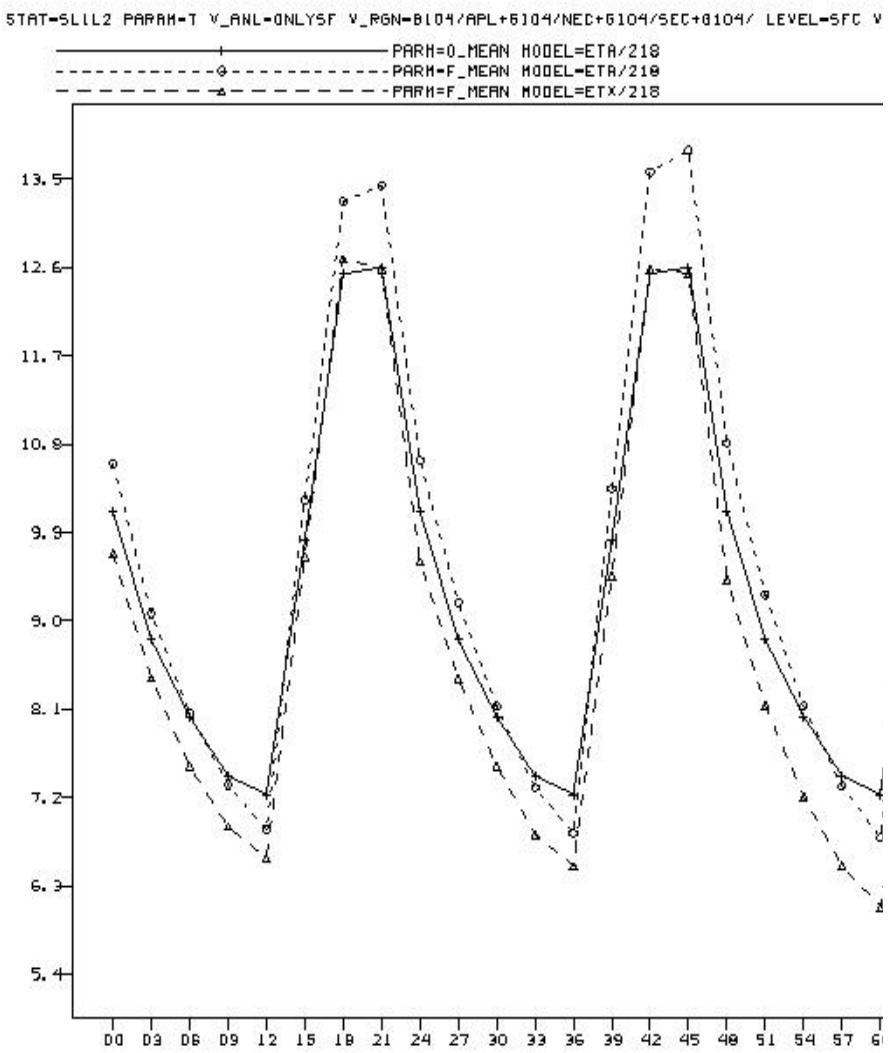
- move soil heat flux calculation to end of SFLX
- small bug fix to calculation of thermal diffusivity of the soil medium
- increase sea-ice albedo from 0.60 to 0.65.

2-m T

West

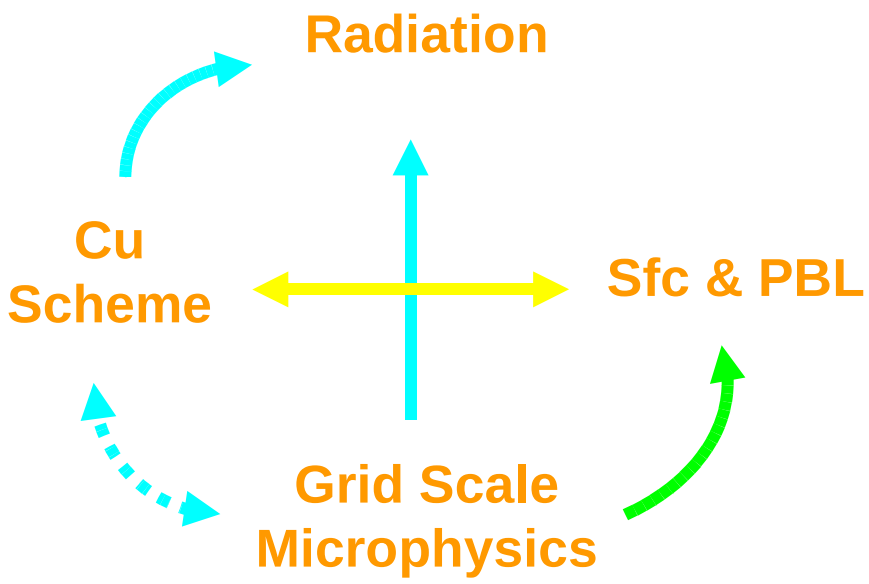


East



"THE PHYSICS WHEEL OF PAIN"

Compliments of
Dr. Jaiyu Zhou
(NOAA/OST)

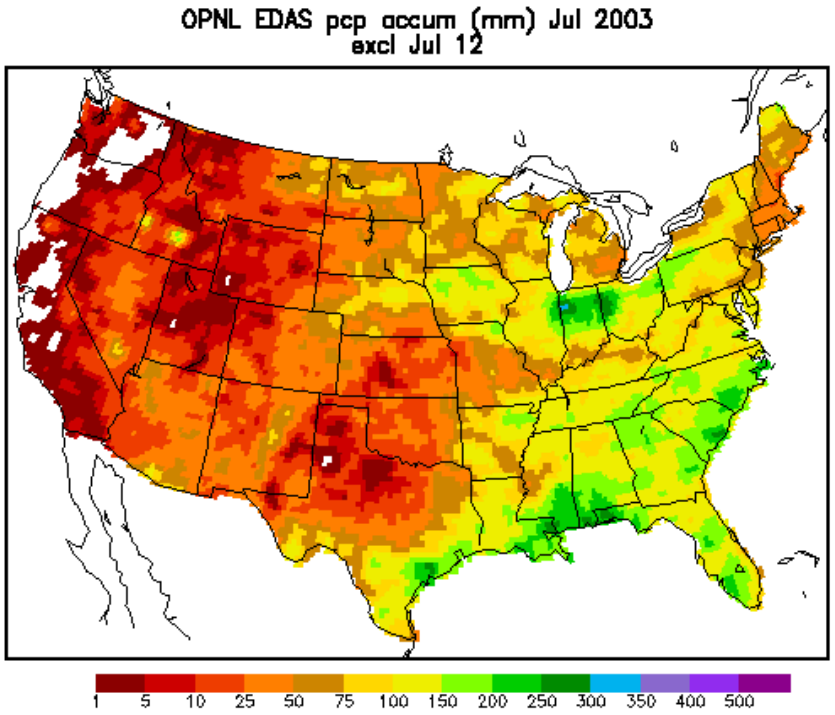


1. - Hydrometeor type (phase)
   - Cloud optical properties
   - Cloud overlap (merging Cu, grid-scale cloudiness)
   - Cloud fractions
5. - Precipitation
6. - Sfc energy fluxes
4. - Convection, PBL evolution, precipitation

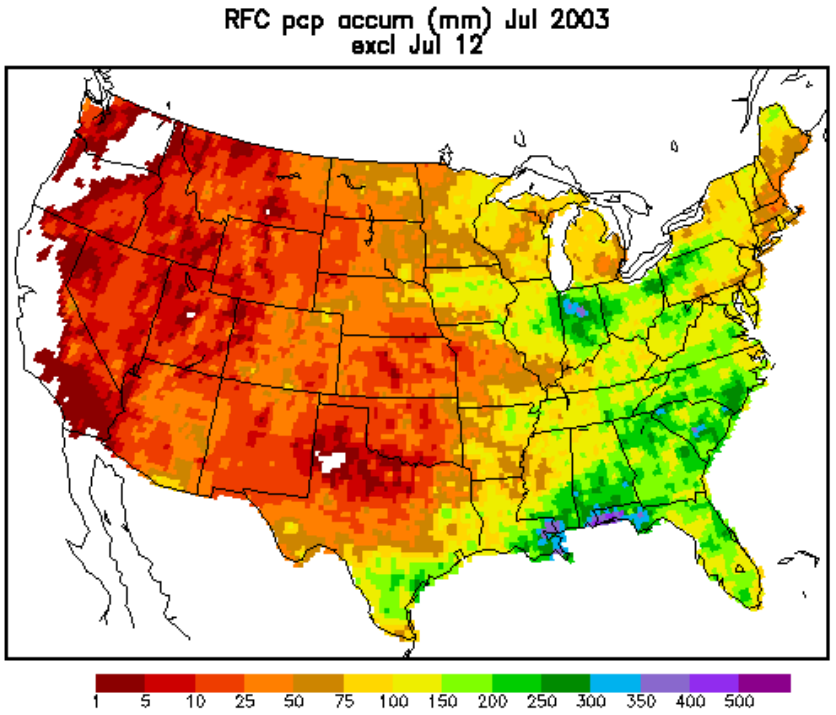
Improving Precipitation Assimilation

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

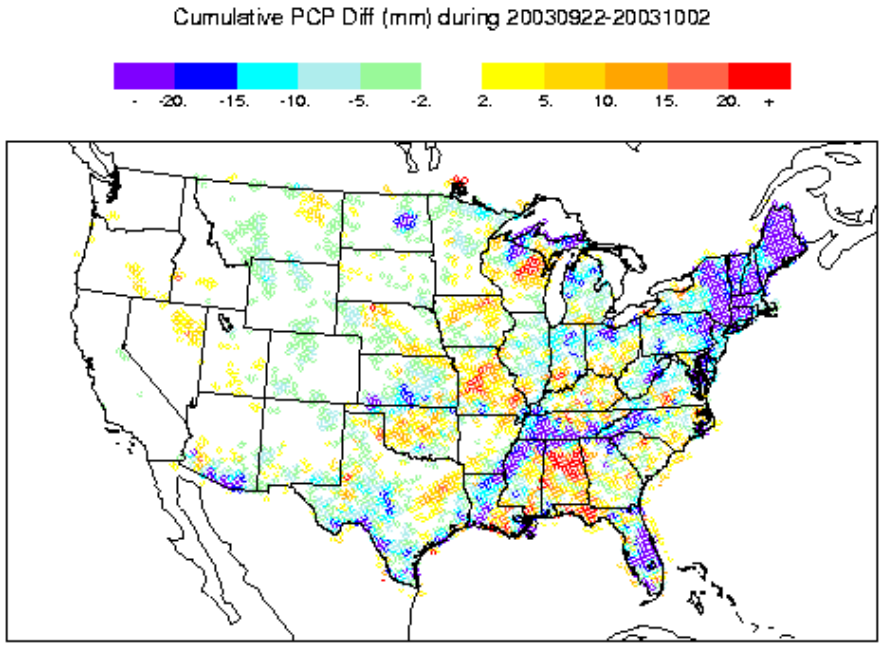


In EDAS



From Daily Gauge analysis

Bias Adjustment of Hourly Analyses for EDAS



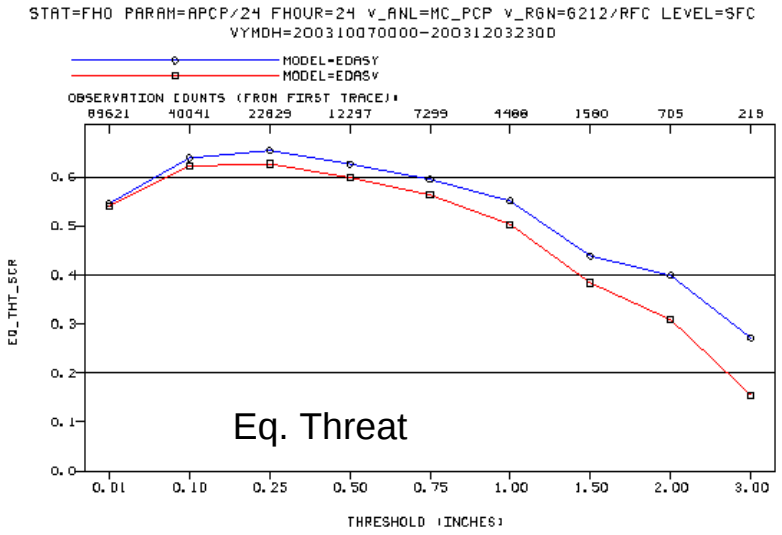
1. Each day, compare 24h EDAS precip (12Z-12Z) to daily gauge analysis
2. Add the difference to a precipitation budget history file

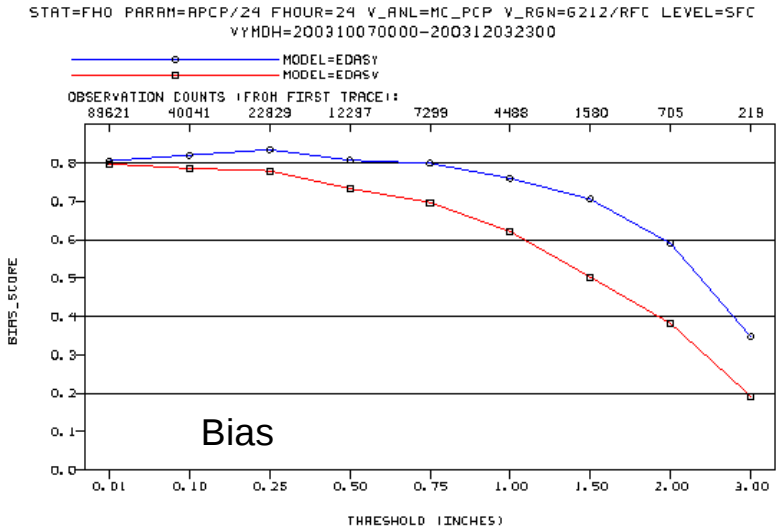
3. Use the budget history file to adjust hourly precip input. Goal: to ‘pay off the debt’ in 1 day. Limit of adjustment: +/- 20% of pre-adjustment total

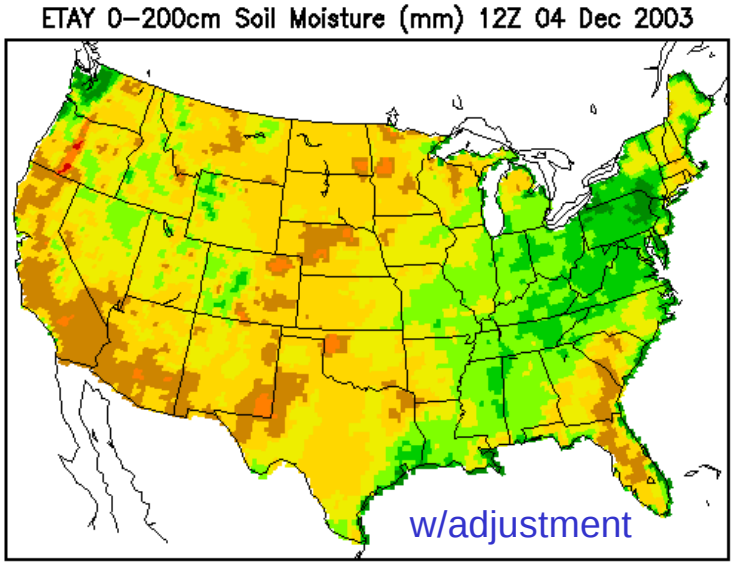
Impact in 32km Parallels, 20031006-20031204

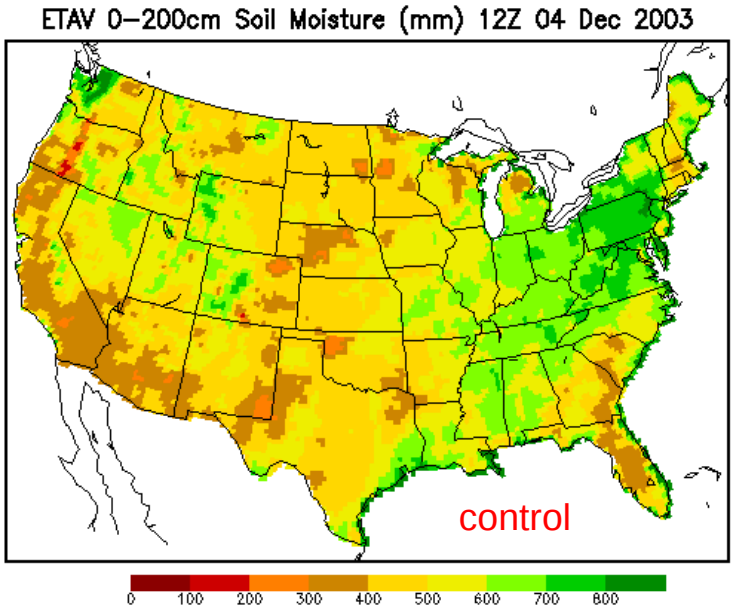
EDAS precip scores

w/adjustment; control





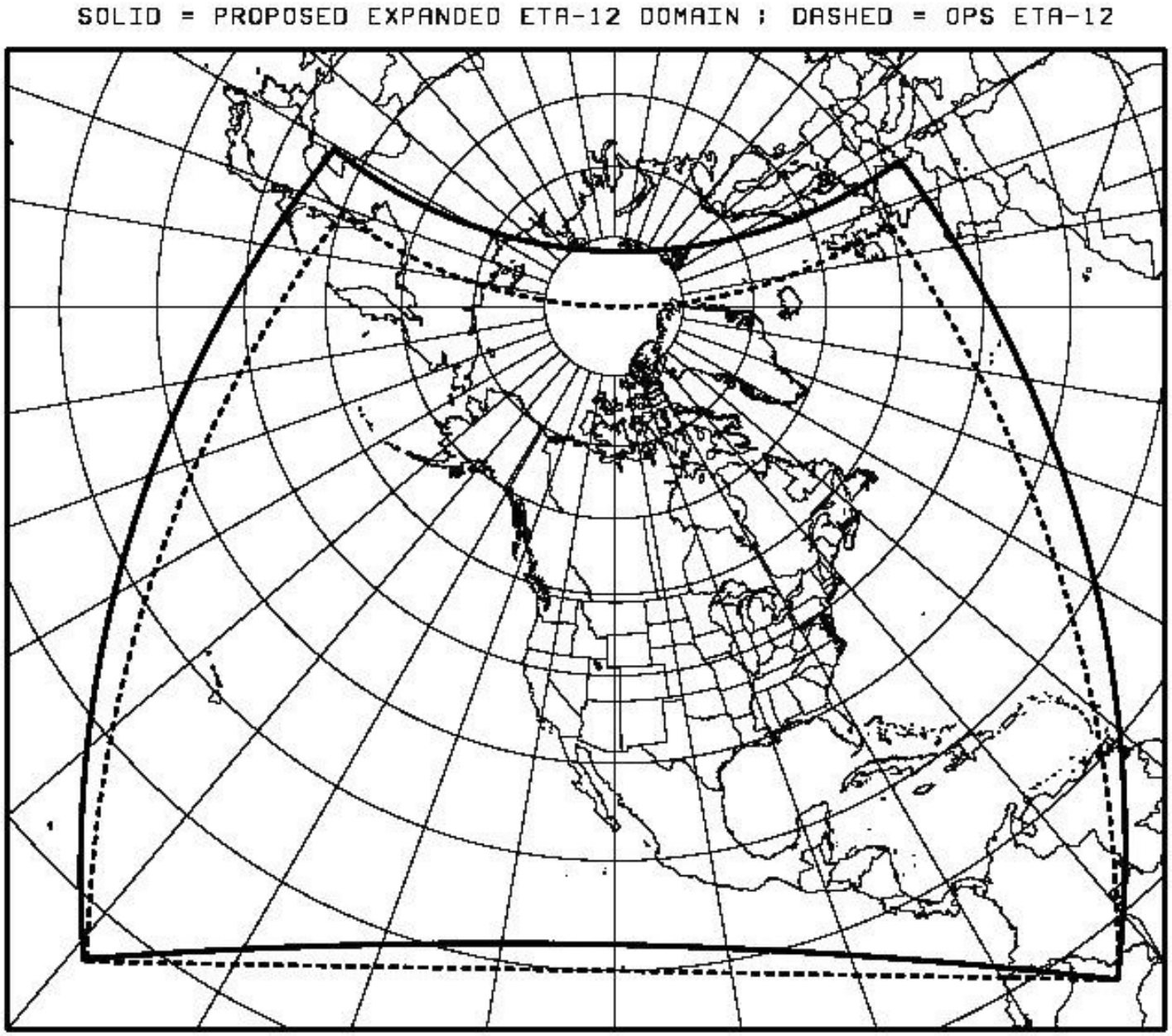




Eta Upgrade Package Targeted for Later 2004 Implementation

- Next [Spring->Summer->Fall] Bundle
  - Replace GFDL radiation with GFS radiation
  - Improve shallow convection
  - Upgrade NOAH Land-Surface Model
  - Start using high resolution land use etc fields
  - Return 3DVAR analysis to using sfc temps over land
  - Begin use of mesonet surface obs, GPS IPW, boundary layer & RASS profiler data, Level 2.5 88D radial velocities
  - Begin assimilation of AIRS radiance data
  - Expand domain by 15%
  - Move model top to 2 mb during data assimilation

Planned 15% Expansion in 2005



Proposed SREF Upgrades Later in FY04

- **Improve lateral boundary conditions from medium range ensembles**
- **Improve breeding scaling factor**
- **Implement SREF at 0300 and 1500 UTC**
- **Improve resolution and/or increase number of members (WRF-NMM)**
- **Implement ensemble mean BUFR files**
- **Implement WRF post for RSM output**
- **Improved and new products**