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

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12 December 2006

Where the Nation's climate and weather services begin

Who We Are

- Government Scientists
  - Tom Black
  - Dennis Keyser
  - Ying Lin
  - Geoff Manikin
  - Ken Mitchell – LSM Ldr
  - Jeff McQueen
  - Dave Parrish
  - Matt Pyle
  - Eric Rogers
  - Wan-Shu Wu
- Visiting Scientists
  - Mike Ek
  - Zavisa Janjic
  - Shun Liu
  - Sei-Young Park - KMA
  - Fedor Mesinger
- Contractor Scientists
  - <- Stacie Bender
  - <- Hui-Ya Chuang
  - Jun Du
  - Brad Ferrier
  - George Gayno
  - S Gopalakrishnan
  - Dan Johnson
  - Dusan Jovic
  - Sajal Kar
  - Pius Lee
  - Guang-Ping Lou
  - Manuel Pondeca
  - Jim Purser
  - Perry Shafran
  - Marina Tsidulko
  - Jeff Whiting
  - Vince Wong
  - Binbin Zhou

T O P I C S

- Recent Changes in Operations & Plans for the Future
  - SREF – 31 August & 6 December 2005
  - Observation Processing - continuous
  - NAM: WRF-NMM replaces Eta and

    GSI replaces Eta 3DVar - 20 June
  - August & September NAM updates
  - December NAM Update
  - Real-Time Mesoscale Analysis (RTMA)
  - Evolution of HiResWindow to meet SPC needs
  - Air Quality Forecast System
  - Downscaling
  - Assimilation & NMM Plans
  - NAM Plans

SREF System Upgrades

Jun Du, Binbin Zhou, Jeff McQueen
Brad Ferrier, Geoff Manikin, Eric Rogers
Henry Juang, Zoltan Toth, Bill Bua

SREF Phase-I Upgrade

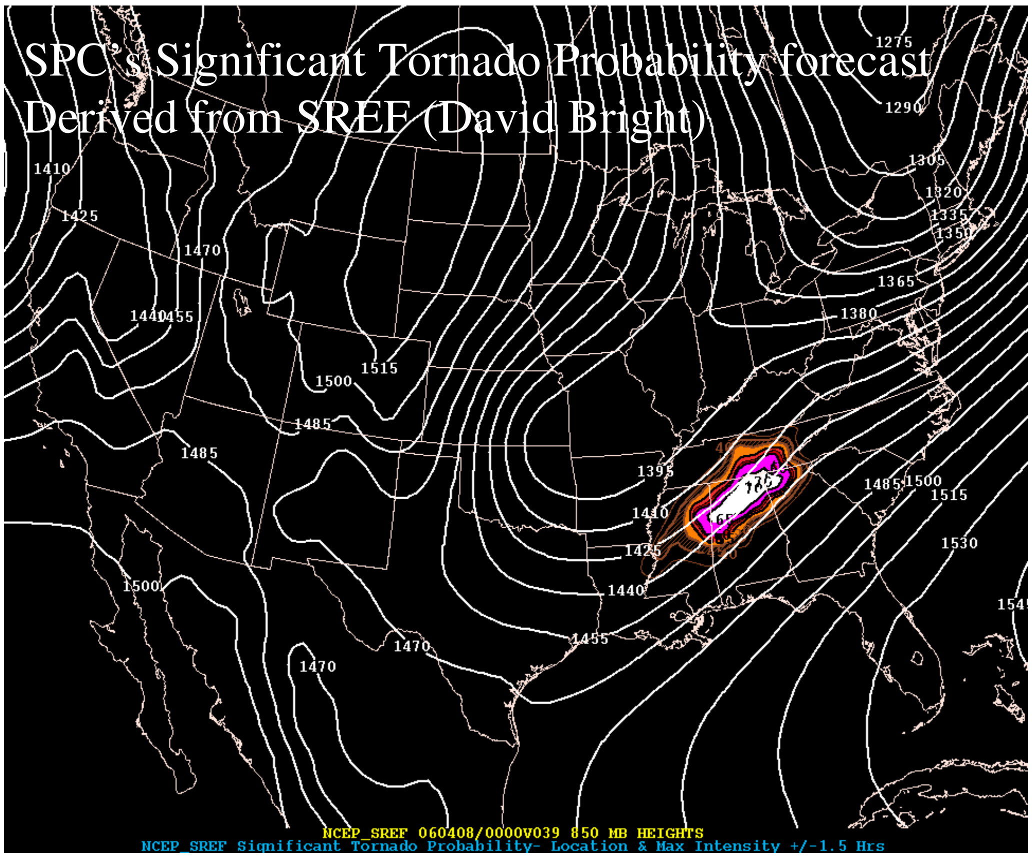
Implemented at 2100z on 31 August 2005

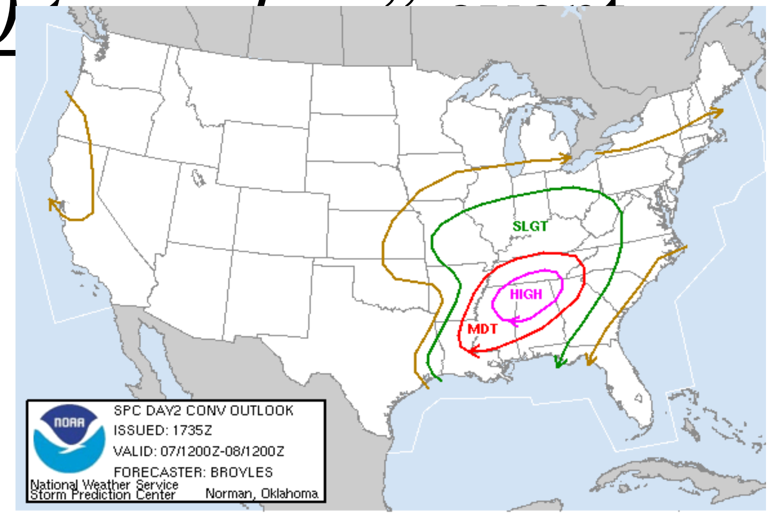
- **Extended forecast range from 63 hr to 87 hr**
- **Domain, products & webpages expanded to include**
  - **Alaska on grid #216 (45 km polar stereo)**
  - **Eastern Pacific (Hawaii) on grid #243 grid (.4 deg lat-long))**
  - **Everything identical to CONUS on grid #212 (40 km Lambert)**
- **RSM changes**
  - Updated & optimized version on expanded domain for AK & HI
  - Hourly BUFR sounding output added (now all 15 SREF members have BUFR output)
  - RSM post is replaced by WRF post
- **3hr-old global ensemble members used as LBCs instead of 9hr-old ones**
- **More global ensemble members used as SREF LBCs for more diversity**

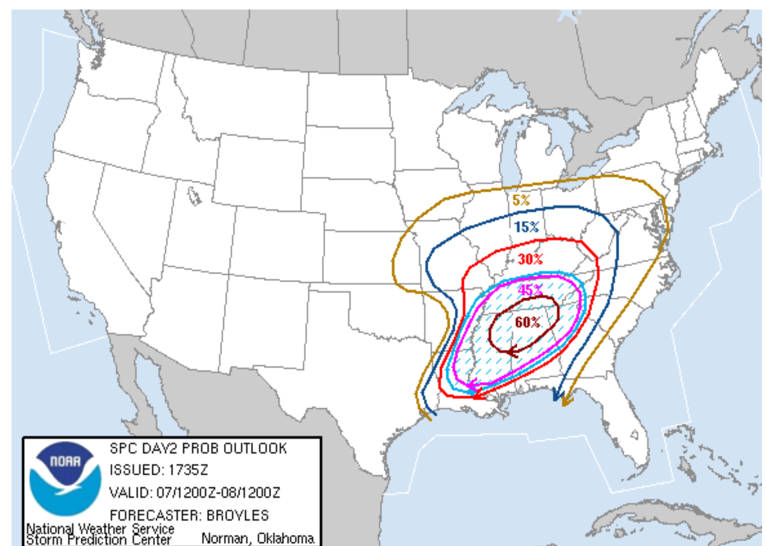
SREF Phase-II WRF Members Added 6 December 2005

- http://wwwt.emc.ncep.noaa.gov/mmb/SREF-Docs/SREF-Nov2005b.ppt
- 6 members (3 WRF_nmm, 3 WRF_arw) providing diversity:
  - two dynamic cores and two physics packages (WRF version 2.0)
  - IC perturbations (breeding method)
  - LBC’s from global ensembles
- North American Domain (CONUS-212, Alaska-216 and Hawaii-243)
- 40 km / 50 levels for NMM 45 km / 35 levels for ARW
- NDAS land surface initial states
- Global analysis (SSI based) used for initial conditions
- Forecast to 87hr with 3hrly output
- Verification against obs and analysis

SPC first-ever Day-2 "High Risk" outlook for April 7, 2006's "*over 60*

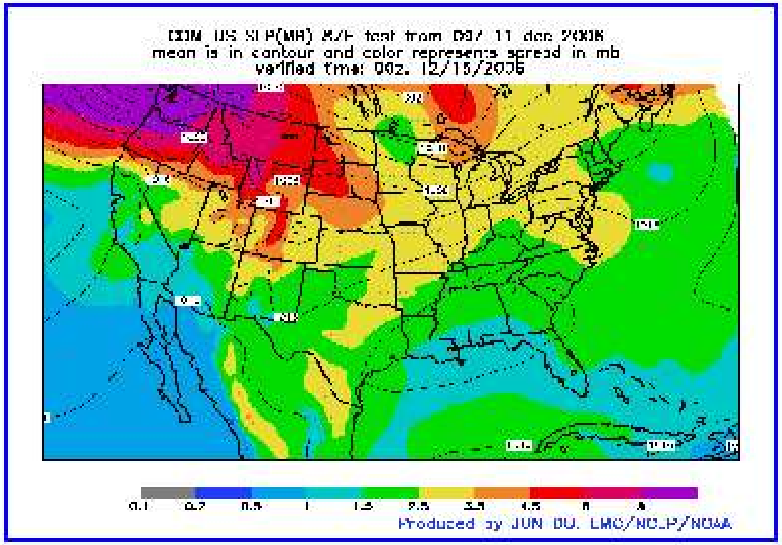






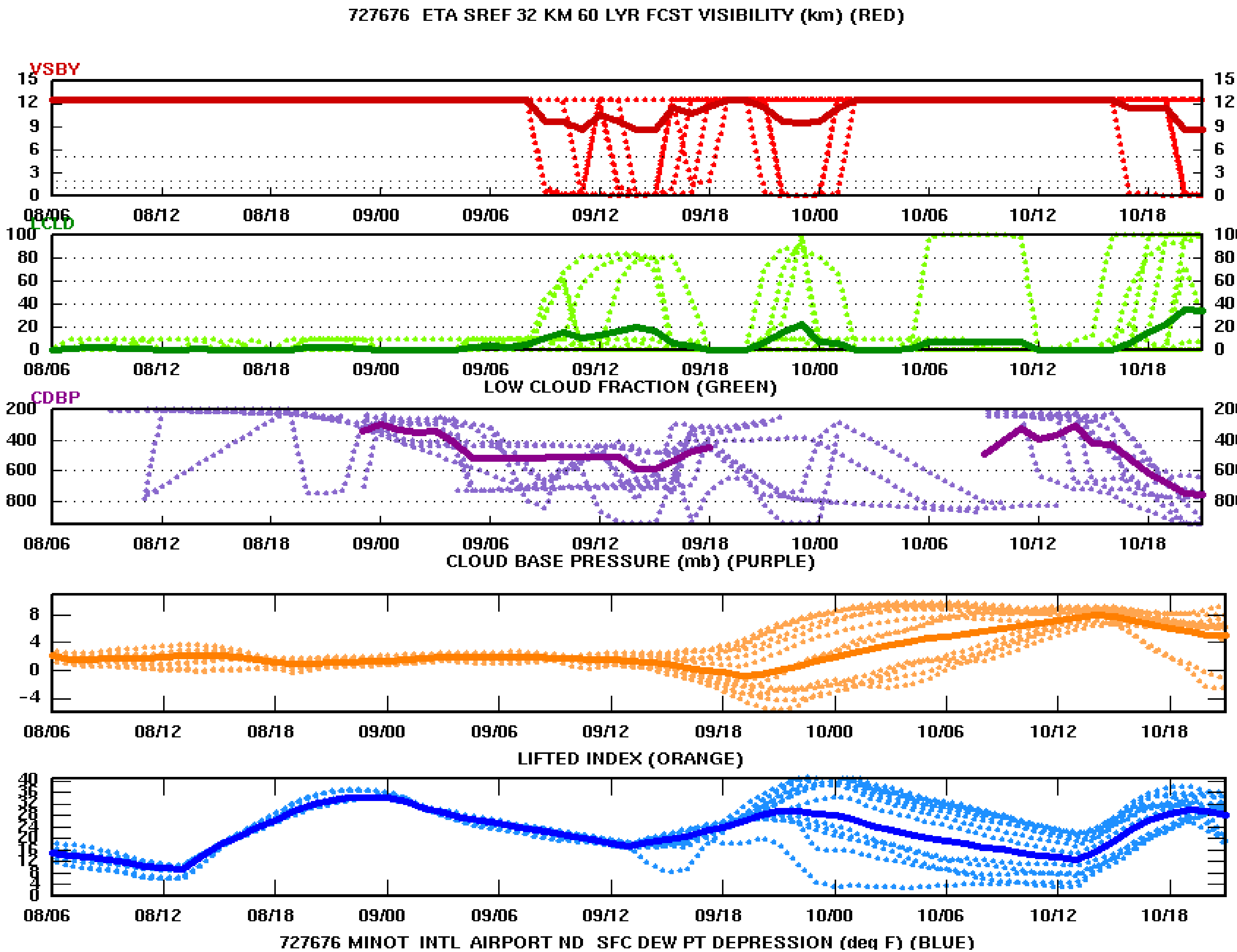
SHORT-RANGE ENSEMBLE FORECASTING (SREF)

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

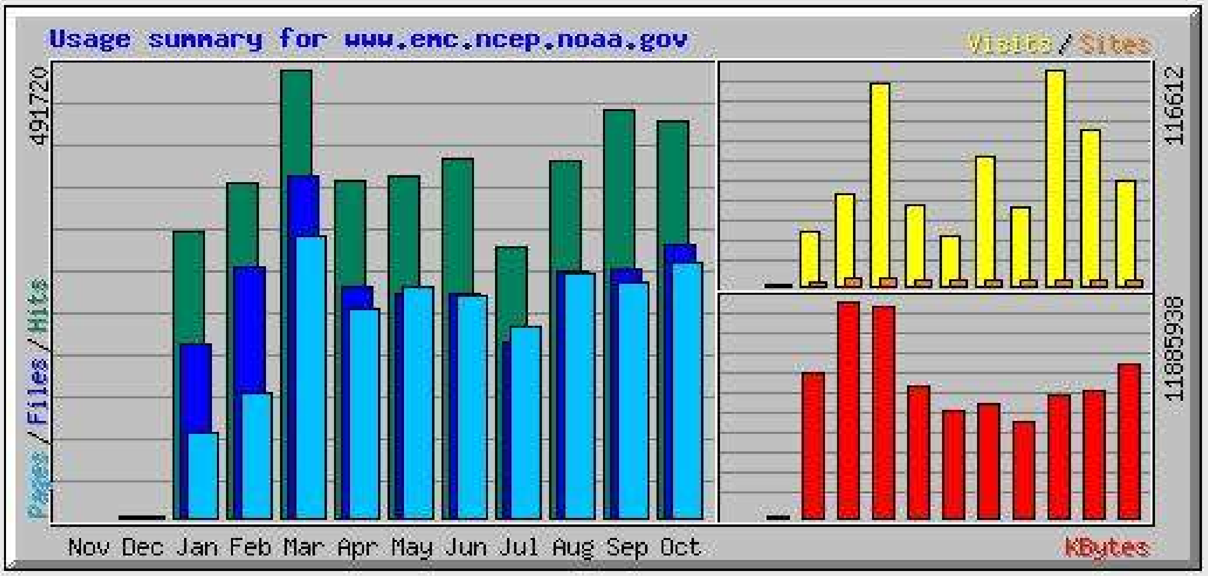


General Weather Forecasting for CONUS, Alaska, and Hawaii regions
A subset of selected fields for Winter Weather (CONUS, Alaska, and Hawaii)
Specific Applications (Aviation, Convection, and Energy)
SREF-based other products: .Bright's plumes (under testing), Manikin's Meteograms, Marchok's Cyclone Tracks
Beijing 2008 Olympic Mesoscale Ensemble Project Testing Page
NCEP/NCO's SREF Guidance Page, Manousos's Winter Weather Impact
online available SREF datasets:NOMADSand NCEP ftp server

Example of SREF Meteogram from BUFR



- EMC site heavily utilized, but …
- It’s not operational
- It runs on dev side
- Therefore, it’s not 100% reliable
- Needs to be transferred to NCO
- A user survey strongly supports this



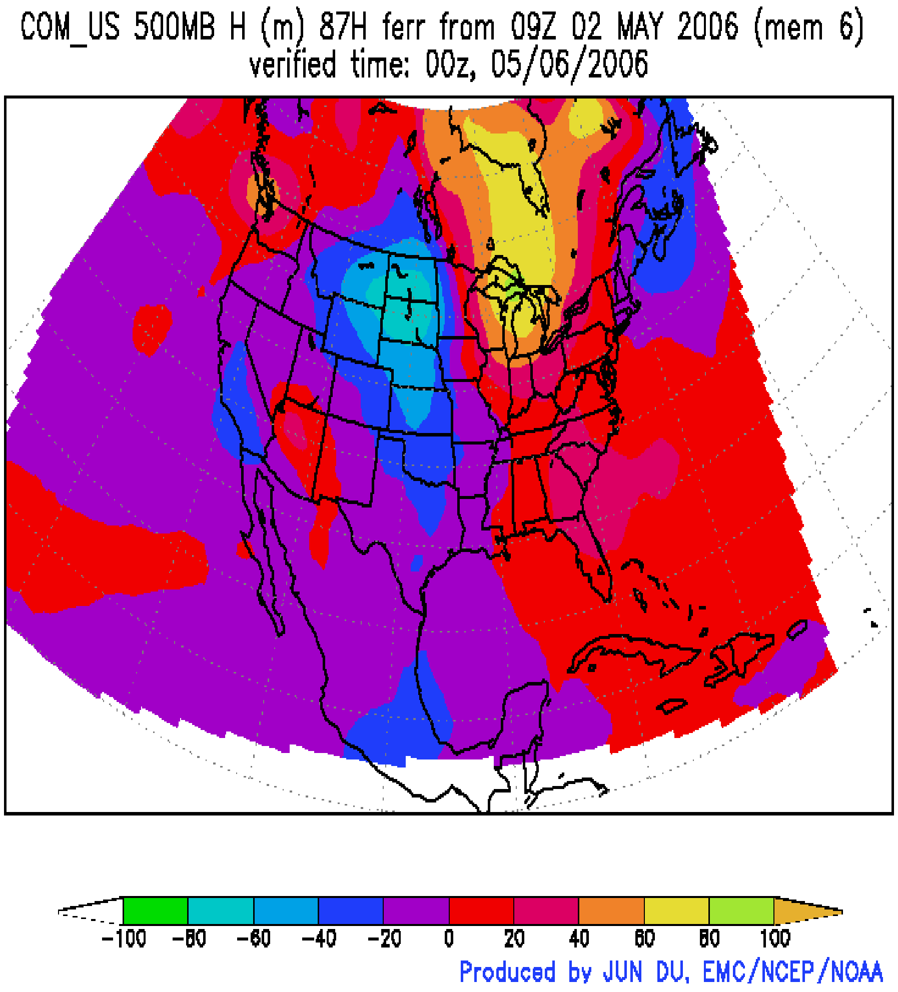
Summary by Month										
Month	Daily Avg				Monthly Totals					
	Hits	Files	Pages	Visits	Sites	KBytes	Visits	Pages	Files	Hits
Oct 2006	15016	10315	9624	1949	3467	8382703	56538	279108	299145	435476
Sep 2006	14867	9045	8620	2789	2903	7026105	83692	258626	271375	446034
Aug 2006	12631	8705	8643	3761	2902	6727309	116612	267938	269864	391590
Jul 2006	9548	6208	6792	1344	3091	5280824	41678	210565	192462	296014
Jun 2006	13131	8221	8138	2324	3250	6206747	69740	244149	246654	393938
May 2006	12043	7926	8129	866	3158	5913219	26875	252015	245730	373343
Apr 2006	12343	8466	7599	1454	3257	7255029	43639	227980	254003	370297
Mar 2006	15861	12069	9995	3514	4022	11553060	108956	309854	374142	491720
Feb 2006	13077	9802	4873	1768	3585	11885938	49504	136467	274460	366166
Jan 2006	10149	6132	3016	924	2270	7930670	28664	93513	190095	314647
Dec 2005	2	1	2	2	2	5	2	2	1	2
Totals						78161609	625900	2280217	2617931	3879227

SREF Plans for 2007

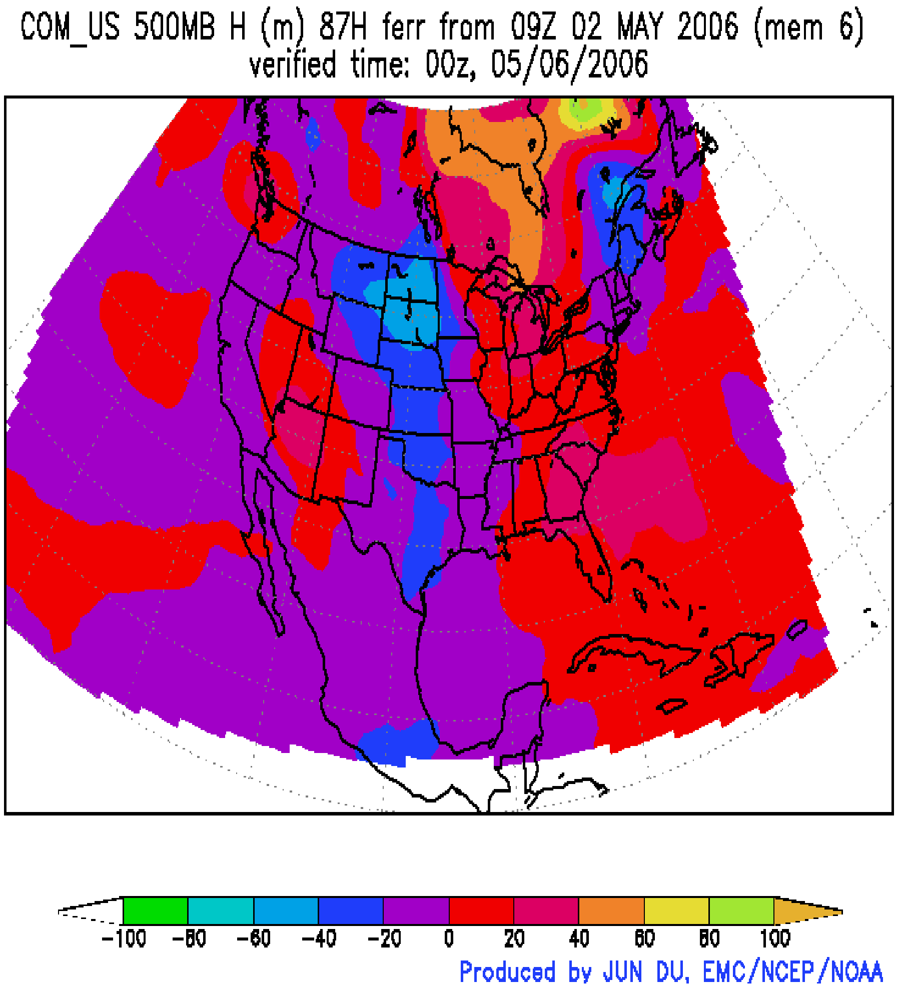
- WRF model upgrade (both NMM and ARW cores) from v2.0 to v2.2
- Move coarse resolution members → 32km
- Bias correction for basic fields
  - For summer, a mixed approach of decaying average (Bo Cui) and hybrid ensembling (Jun Du)
  - By winter, precipitation (GSD's HuilingYuan)
- Soil moisture perturbation to increase spread of near-surface variables
- BUFR output from WRF members
- Data availability in AWIPS

Post-processing with Hybrid-Ensembling approach (Du, 2004): fcst error of 21-mem ens mean of 500mb H at 3.5 days

Raw SREF fcst error



Hybrid SREF fcst error



Bias correction of PQPF Over the central U.S., day 3

Reliability Diagrams

Cross validation

blue: old, red: new

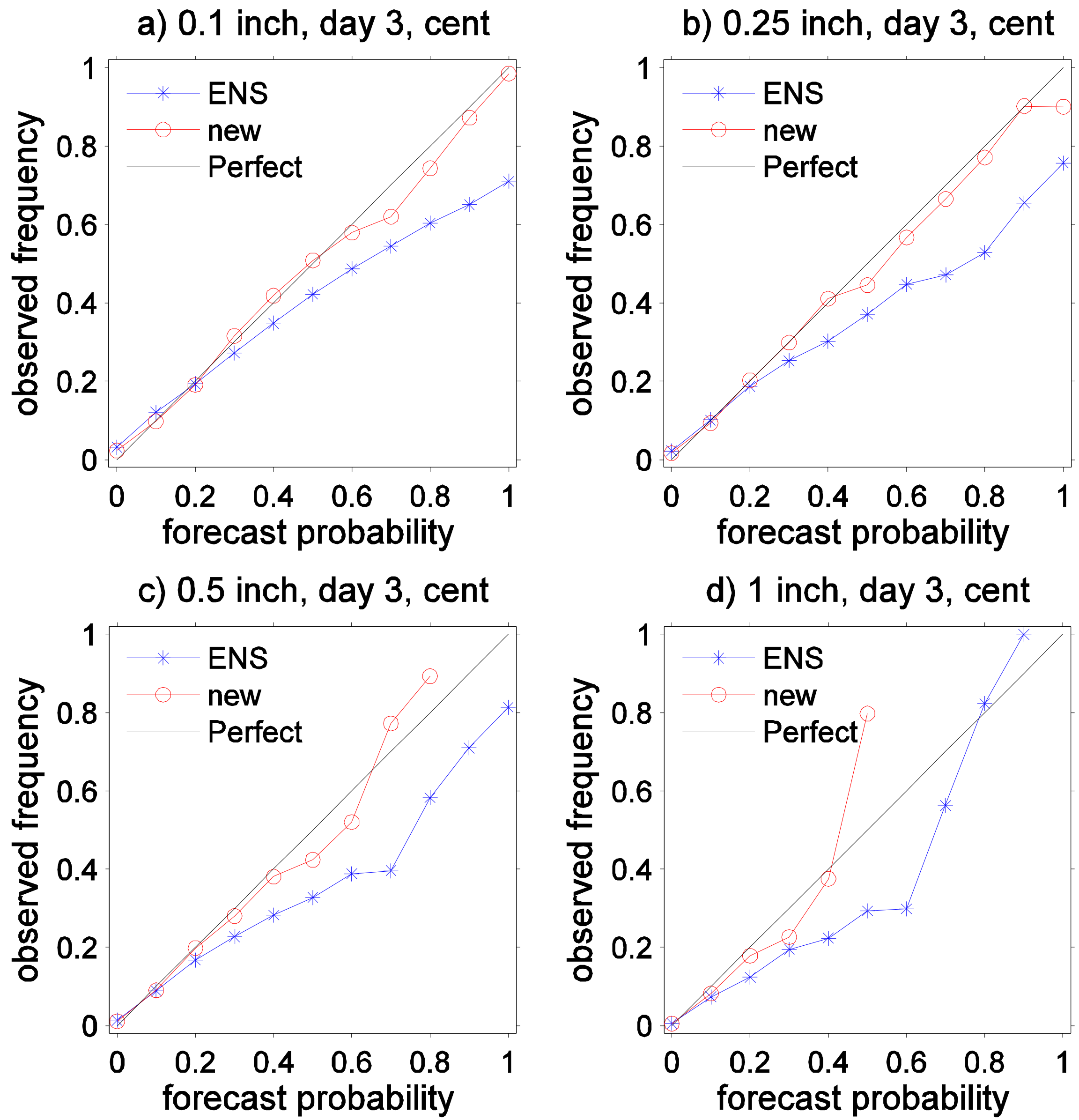
2006 April-Sept.

Thresholds: 0.1, 0.25, 0.5, 1 inch /24 h

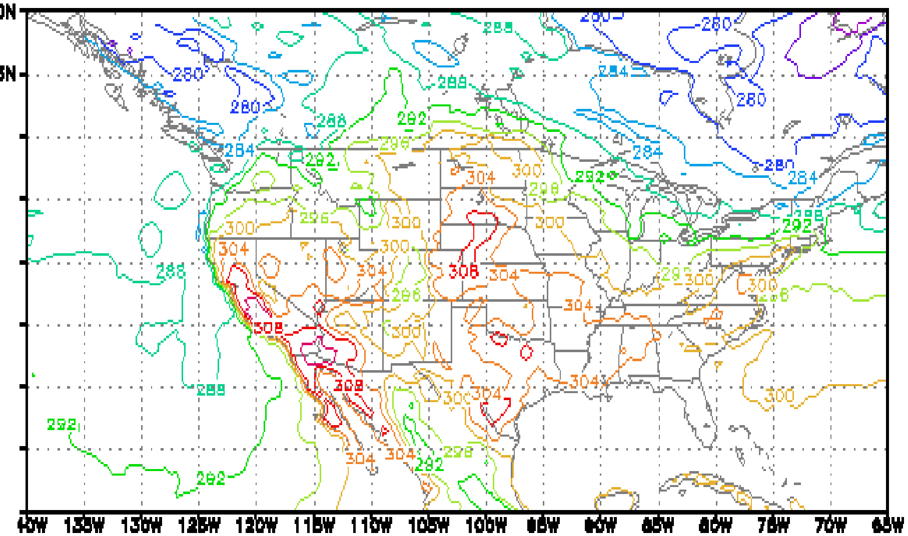
Reliability improved

Lack high probabilities for higher thresholds

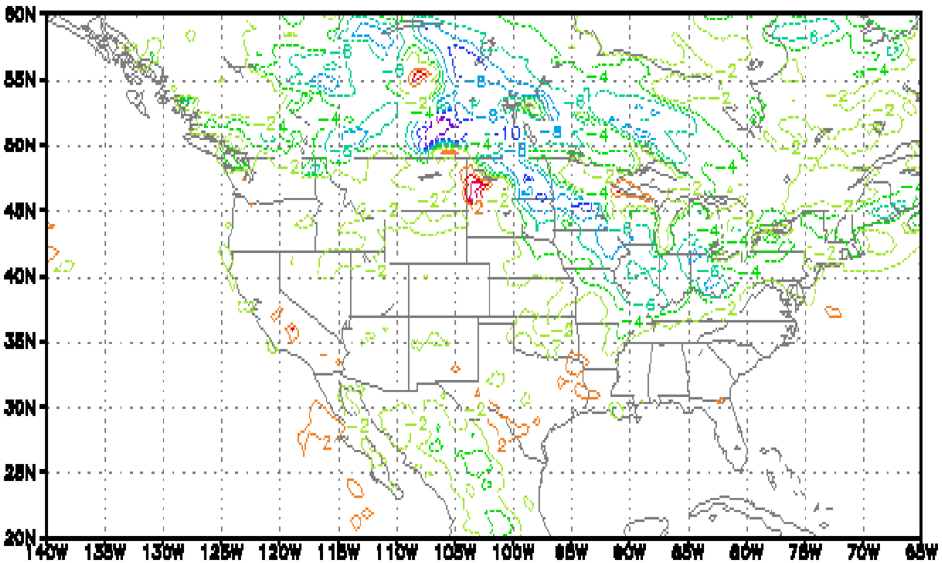
(Huiling Yuan/GSD, 2006)



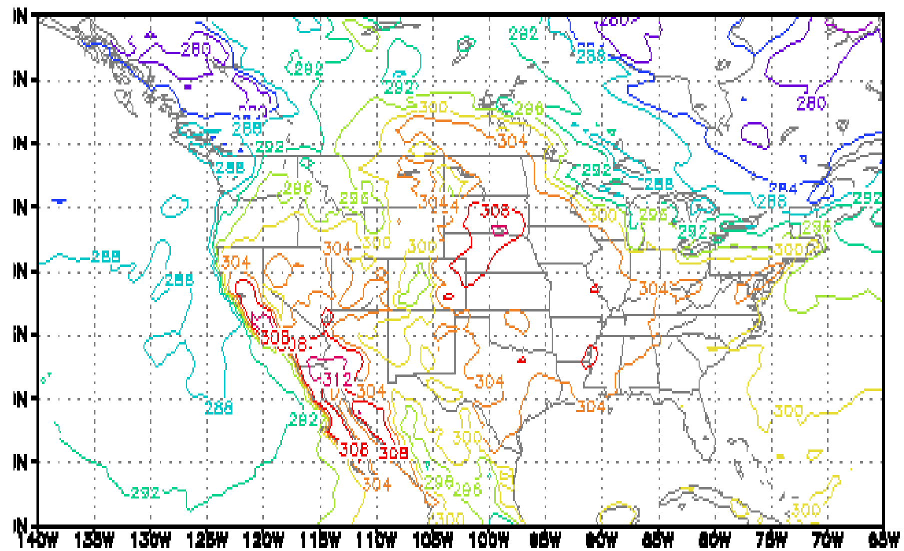
Within WRF_NMM model: Impact of soil moisture on T2m is significant!



With nam soil moisture (NMM)



T2m diff (namSM – gfsSM, NMM)



With gfs soil moisture (NMM)

SREF Variables in AWIPS OB7.2

Means/Spreads

- Heights at 1000, 850, 700, 500, 250 mb
- U+V at 1000, 850, 700, 500, 250 mb & 10 m
- Temperature 850, 700, 500 mb & 2 m
- Dew Point (RH) 850, 700, 500 mb & 2 m
- QPF at 3, 6, 12 and 24 hour totals
- 12-hr Snowfall
- Sea Level Pressure
- Precipitable Water

Probabilistic Fields

- 3-hr/6-hr QPF GE .01”, .25”, .50”, 1.0”
- 12-hr/24-hr QPF GE 01”, .25”, .50”, 1.0”, 2.0”
- 12-hr Snowfall GE 1”, 4”, 8”, 12” (have 2.5, 5, 10, 20”)
- Temperature at 2 m & 850 mb LE 0^{o}C
- 10 m Wind GE 25 kt, 34 kt, 50 kt
- CAPE GE 500, 1000, 2000, 3000, 4000
- Lifted Index LE 0, -4, -8
- Surface Visibility LE 1 mi, 3 mi
- Cloud Ceiling LE 500 ft, 1000 ft, 3000 ft
- Probability of precipitation types (have rain, frozen, & freezing)

Observation Processing

- Prepared for observation subtype (e.g. airframe or mesonet provider)
- Adapted NRL aircraft QC package
  - Includes improved track-checking
- Ascent/descent reports generated as profiles
  - For use in validating boundary layer etc
  - For use in grid-to-obs verification
  - For the period 01-05 Dec average # daily profile reports:
    AIRCFT = 693 GFS 273 NAM
    AIRCAR = 1291GFS 426 NAM
    AIRCFT includes: ASDAR/AMDAR, RECCO/DROPS, TAMDAR + CAMDAR
    AIRCAR includes MDCRS ACARS from ARINC
- NSSL merged Level II Radar QC package combines
  - Radial wind (used reflectivity) module written in Fortran
  - Reflectivity (used winds) module written in C++ rewritten in Fortran

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

Mesoscale Modeling Branch

Geoff DiMego

7 June 2006

http://www.emc.ncep.noaa.gov/WRFinNAM/Update_WRF-NMM_replacing_Eta_in_NAM2.pdf

What Was Proposed

- **Replace Eta Model with WRF version of Nonhydrostatic Mesoscale Model (NMM)**
  - WRF Common Modeling Infrastructure
  - Non-hydrostatic dynamics
  - Use of hybrid sigma-pressure vertical coordinate
  - Extended model top to 2 mb
  - Refined advection, diffusion, numerics and physics
- **Replace Eta 3D-Var analysis with Gridpoint Statistical Interpolation (GSI) analysis**
  - Unified (regional + global) 3D-Variational analysis adapted to WRF
  - Begin use of background errors based on WRF-NMM to 2 mb
  - Use of new variable for moisture analysis (coupled to temperature)
  - Use of dynamically retuned observational errors

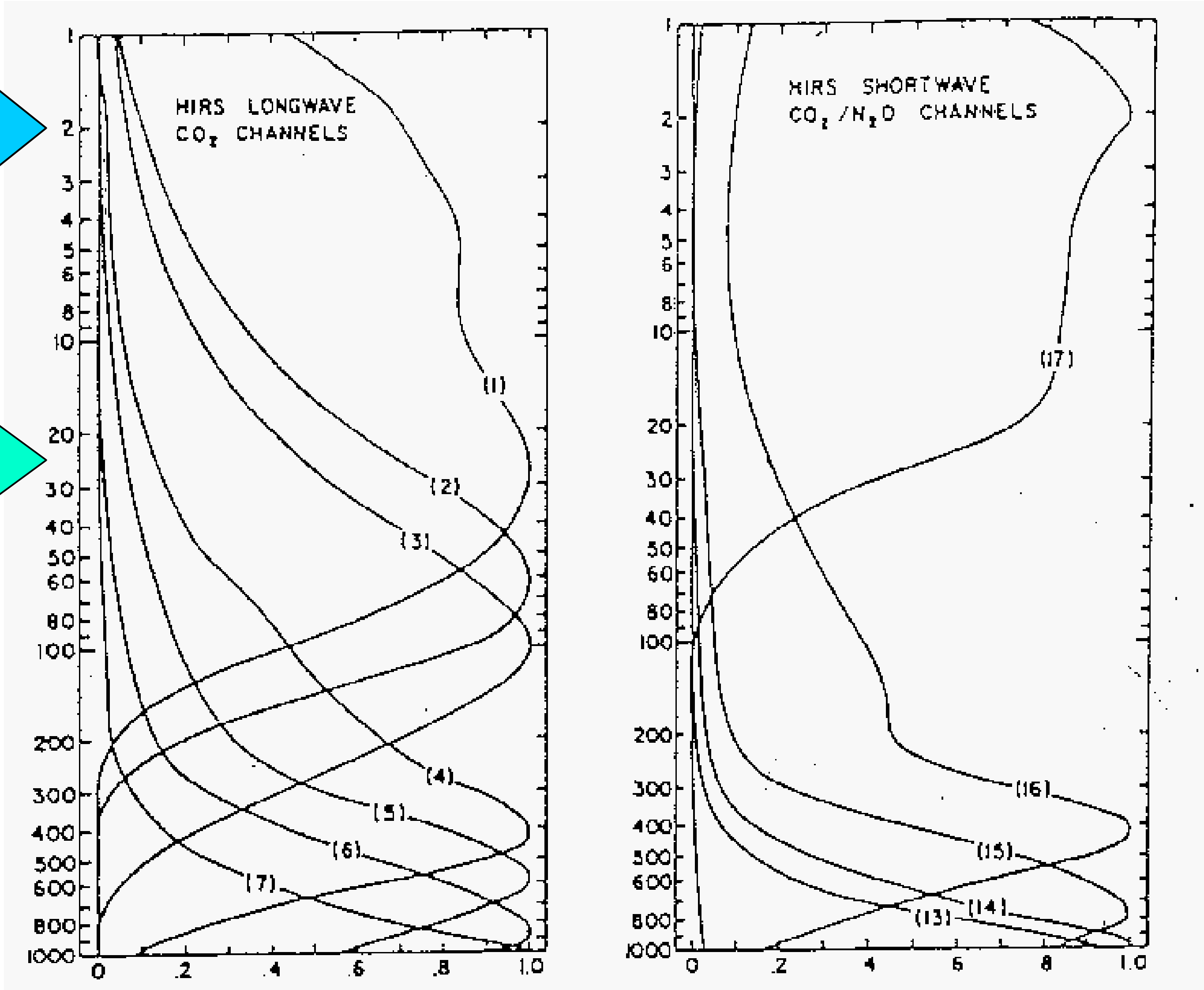
Other NDAS Changes

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

TOVS/HIRS Satellite Channel Weighting Functions and Model Top Pressure

New top 2 mb

Old top 25 mb



Pre-Implementation Issues

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

Real-Time Parallel Stats

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

1. PRECIPITATION THREAT AND BIAS SCORES

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

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

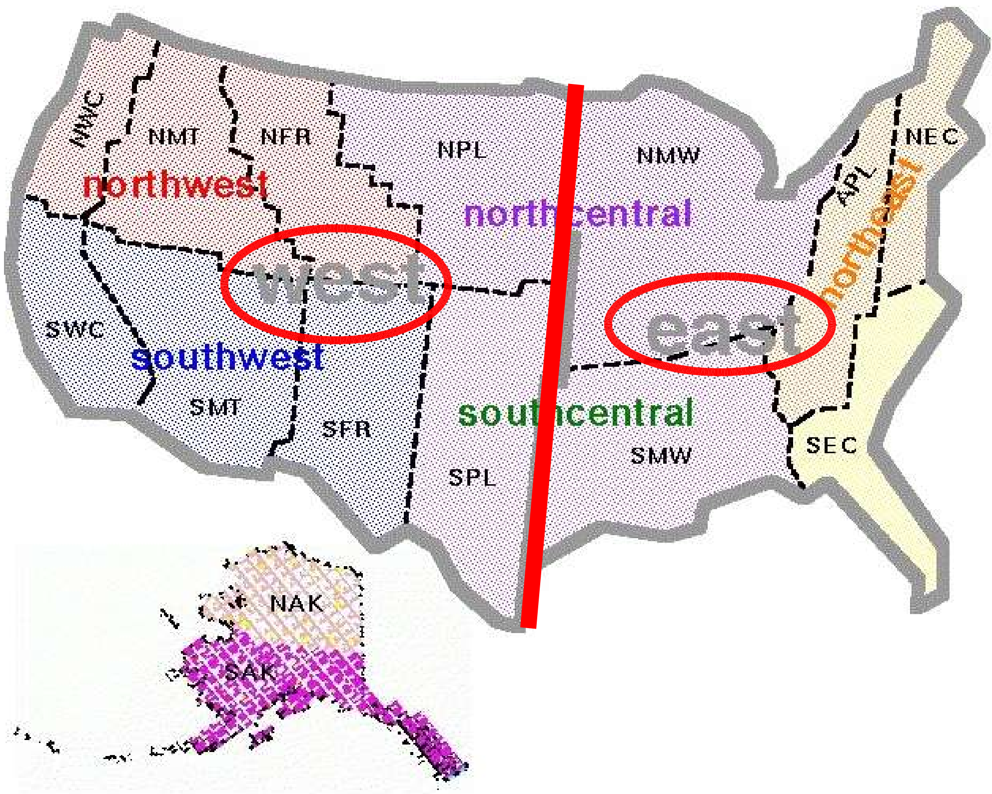
2. UPPER AIR RMS STATISTICS (12, 24, 48, 60, and 84-h forecasts)

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

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

3. NEAR-SURFACE STATISTICS

Verification Regions:



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

Real-Time Monitoring Webpage

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

Performance Summary & Remaining Issues

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

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

All Evaluation Materials

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

Briefing on WRF in NAM (.pdf) **- June 7th, 2006**

Geoff Dimego

Evaluations

- **WRF in NAM Training Package**
  Stephen Jascourt
- **NAM-WRF Implementation Technical Decision Briefing**
  David Michaud & John Ward
- **AWC Evaluation of the NAM-WRF-NMM Parallel**
  Dr. S. Silberberg & AWC Forecast Staff
- **SPC Evaluation of the NAM-WRF Model: Spring Experiment 2006**
  Steven Weiss & Jack Kain
- **Update of Additional SPC Feedback for NAM-WRF Evaluation**
  Steven J. Weiss
- **Model Implementation Subjective Evaluation Report - OPC**
  Joe Sienkiewicz, OPC
- **Model Implementation Subjective Evaluation Report - NCEP HPC**
  Peter Manousos, HPC Science & Ops Officer
- **Model Implementation Subjective Evaluation Report - National AQ Forecast Capability**
  Davidson
- **Feedback on NAM (Eta) to NAM (WRF-NMM)**
  Earl S. Barker, AFWA/XPFT
- **WRF-Evaluation**
  Dave Danielson, NWS WFO, Oxnard, CA
- **Model Implementation Subjective Evaluation Report**
  Carven Scott and James Nelson, WFO Anchorage
- **Parallel NAM - SLC Evaluation**
  Randy Graham and Alex Tardy, WFO Salt Lake City
- **Model Implementation Subjective Evaluation Report - CR NWP Team**
  Tom Hultquist, Central Region
- **Model Implementation Subjective Evaluation Report - ER**
  Jeff Waldstreicher, Eastern Region
- **Model Implementation Subjective Evaluation Report - SR**
  Bernard Meisner, Southern Region
- **Two Cases Of Trough Over-deepening In NAM-WRF**
  Stephen Jascourt
- **Private Sector Evaluator #1**
- **Private Sector Evaluator #2**

Subjective Evaluation Summary

NCEP Center	Recommendation
AWC	
SPC	
HPC	
OPC	

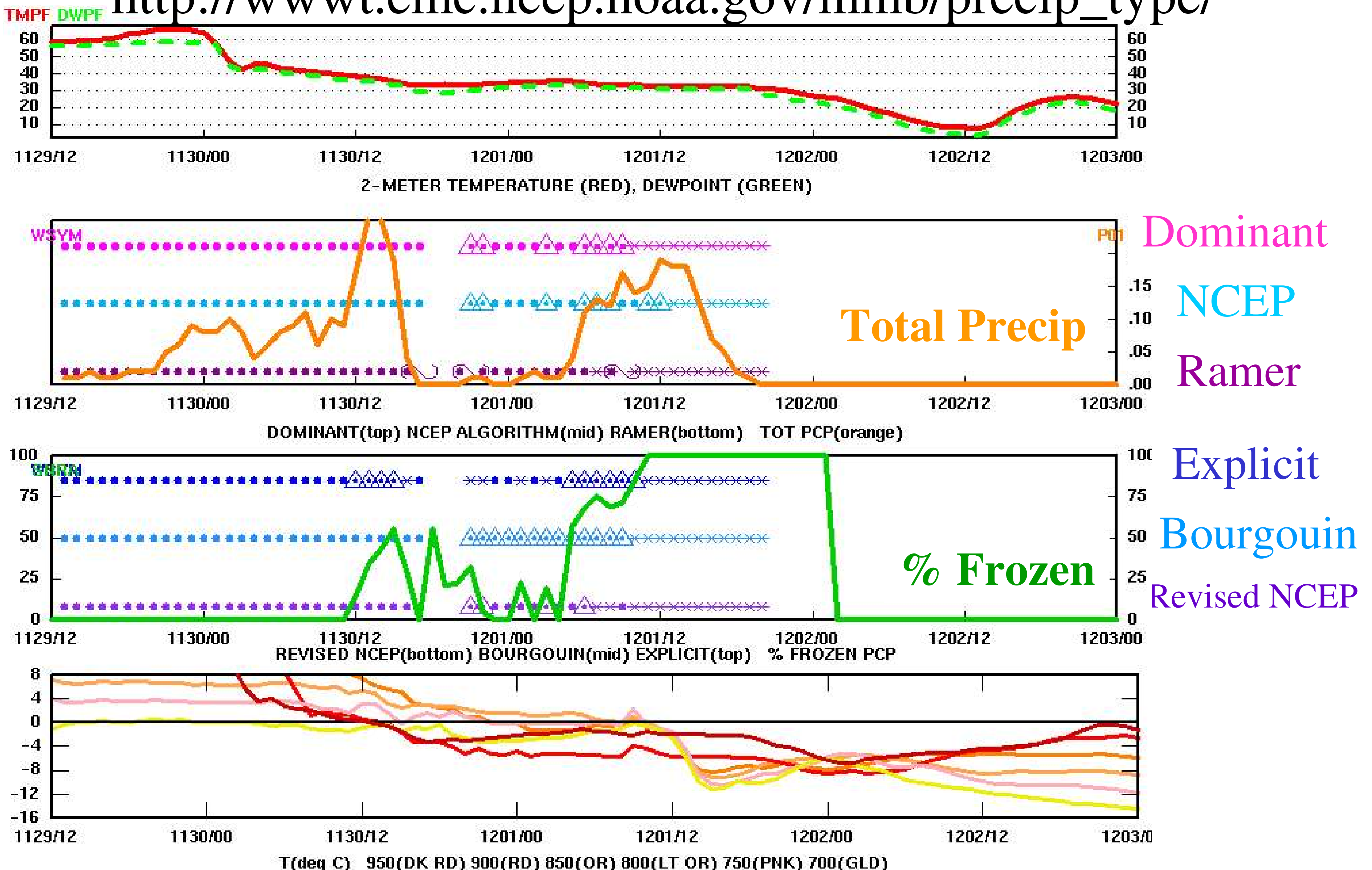
Non-NCEP	Recommendation
Alaska Region	
Central Region	
Eastern Region	
Southern Region	
Western Region	
Air Quality Program	

NAM-MOS & FWIS

- Application of current MOS (derived from Eta forecasts) to WRF-NAM produced degraded quality
- NCEP to run an interim Eta-32
  - In a portion of unused Fire Weather / IMET Support runslot
  - Using SREF 32 km control member code
  - Initialized off NAM analysis (WRF-GSI)
  - Same lateral boundary conditions as NAM (off-time GFS)
- NAM-MOS will have same availability as today
- MOS only product to be distributed
- Likely to continue well into 2007
- Could reinstate FWIS run with upgraded computer power of dew/mist (OSIP?)

Sample Manikin's New Precipitation Type Webpage – Gary, Indiana

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



15 August NAM Upgrades

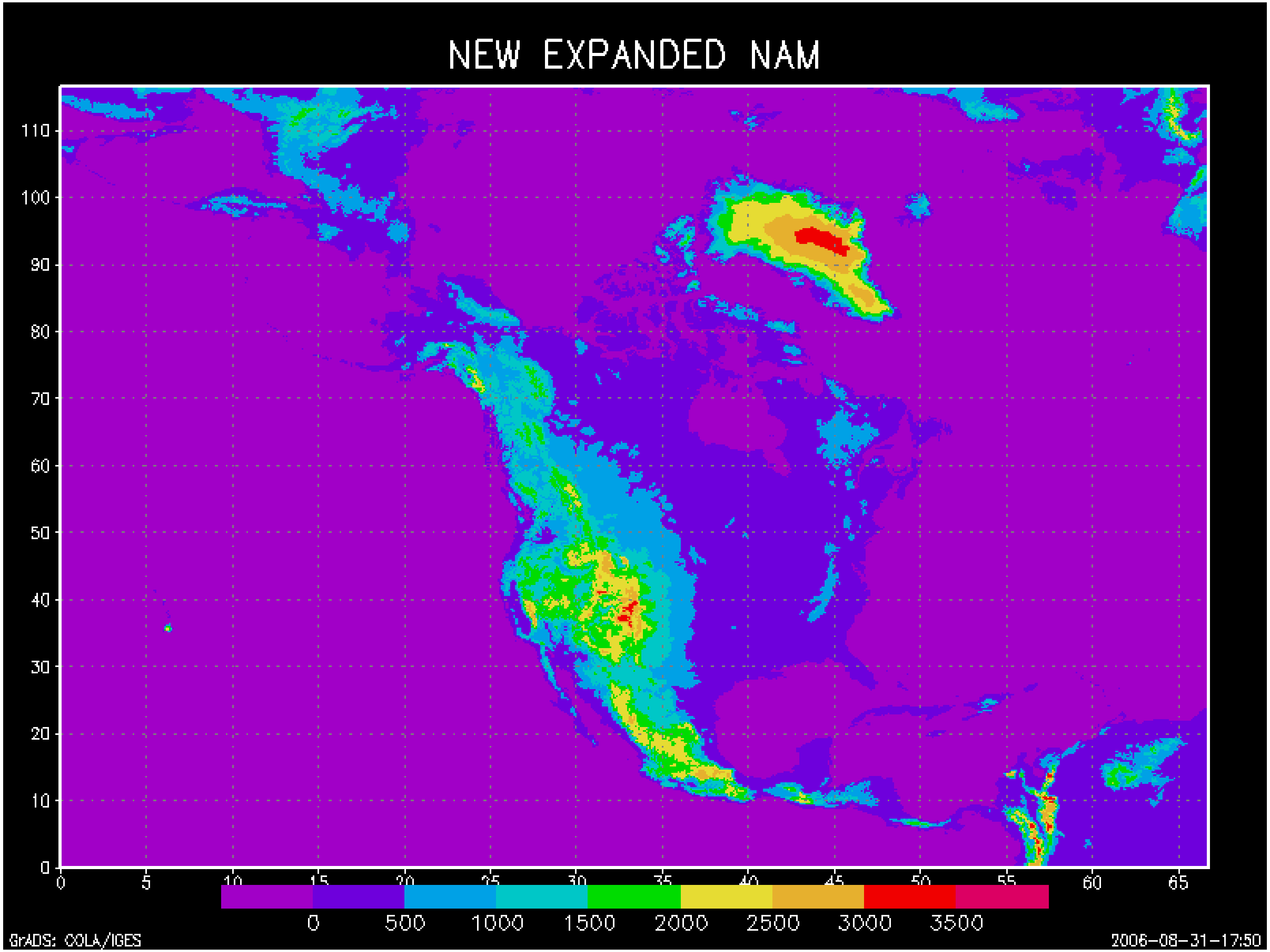
- Remove any restrictions to horizontal diffusion between water points at different elevations (e.g., between erroneously sloping water points and water points at sea-level)
- Allow horizontal diffusion at grid points along coastal/ice boundaries where the slope between neighboring grid points is > 6 m
- Enhanced vertical diffusion
- Redefine roughness length z0=z0base (veg component) + z0land, removing terrain height component
- Turn on assimilation of surface temperature data over land in the GSI
- Modified the SST preprocessing job to use new climatological values for **Great Salt Lake** water temperatures from the University of Utah; a cosine fit to the bimonthly observational data from Saltair Boat harbor (from 1972-1989). From Steenburgh et al., 2000: Climatology of Lake-Effect Snowstorms of the Great Salt Lake. Monthly Weather Review, 128, 709-727.
- Modified the SST preprocessing job to use monthly climatological values of water temperature for the **Salton Sea** in southern California
- Modified the SST preprocessing job to use monthly climatological values of water temperature (obtained from the Army Corps of Engineers) for **Fort Peck Reservoir** in Montana

5 September NAM Upgrades

- Increased Smagorinsky constant for lateral diffusion from 0.27 to its maximum value of 0.4; this was inadvertently left out of the 8/15 changes for the NAM, it was implemented in the DGEX on 8/15
- Revert back to using the 1/2 degree RTG_SST analysis used in the NAM-Eta due to problems with a persistent cold bias in the hi-res (1/12th degree) RTG_SST analysis in and north of the Bering Strait and in Hudson's Bay.

New NAM Land-Sea Mask and Orography

- Create new landmask and orography for expanded (~22%) NAM domain.
  - To be implemented ’07.
- Fix problems with current mask/orog.
  - Great Salt Lake too big.
  - Waterfalls.
  - Terrain not smooth enough.



NEW EXPANDED NAM
110
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
0
500
1000
1500
2000
2500
3000
3500
GrADS: COLA/IGES
2006-08-31-17:50

19 December 2006 Crisis Change

Background

- **Since August, in response to poor NAM performance, EMC has run two separate parallels testing upgrades**
- **Poor performance includes**
  - **Overdevelopment of mid-latitude cyclones**
  - **Exaggerated "digging" too far south**
  - **Convection (deep & shallow) triggering issues**
- **Parallel runs are:**
  - **In data assimilation: new divergence damper with extra damping of the external mode, applied (5x) more heavily in NDAS to reduce noise**
  - **Tuning convection and microphysics**
- **Two parallel runs were combined for final testing beginning 2 November**
- **Codes (after speeding them up) turned over to NCO on 27 November**

December 2006 Crisis Change

http://www.emc.ncep.noaa.gov/mmb/namchanges_dec2006/NAM_Upgrades.Nov2006.html

1. THE DIVERGENCE DAMPING ROUTINE, WHICH DAMPS ALL GRAVITY-INERTIA AND EXTERNAL MODES, IS CHANGED TO INCREASE DAMPING OF THE EXTERNAL MODE.

2. DURING THE NDAS, DIVERGENCE DAMPING IS INCREASED TO 5X THAT USED DURING THE 84 HR NAM FREE FORECAST.

3a. NUMEROUS CHANGES ARE MADE TO CONVECTIVE PARAMETERIZATION:

- TRIGGERING OF DEEP AND SHALLOW CONVECTION IS CONSIDERED ONLY FOR GRID POINTS WITH POSITIVE CAPE THROUGHOUT A PARCEL'S ASCENT; THE SEARCH FOR PARCEL INSTABILITY IS EXTENDED TO INCLUDE NOT ONLY WHETHER THE MOST UNSTABLE /HIGHEST THETA-E/ PARCEL CAN SUPPORT CONVECTION, BUT ALSO WHETHER PARCELS ORIGINATING AT HIGHER LEVELS BECOME POSITIVELY BUOYANT WHEN LIFTED TO THEIR LCL. CONVECTIVE ADJUSTMENTS ARE MADE WITH RESPECT TO THE PARCEL ASSOCIATED WITH THE GREATEST INSTABILITY /LARGEST CAPE/.

- THE SEARCH FOR THE MOST UNSTABLE PARCEL IS EXTENDED FROM THE LOWEST TWENTY PERCENT OF THE ATMOSPHERE TO THE LOWEST 40 PERCENT OF THE ATMOSPHERE.

December 2006 Crisis Change

http://www.emc.ncep.noaa.gov/mmb/namchanges_dec2006/NAM_Upgrades.Nov2006.html

3b. NUMEROUS CHANGES ARE MADE TO CONVECTIVE PARAMETERIZATION (continued)

- WATER LOADING EFFECTS ARE NOW INCLUDED IN ASSESSING THE BUOYANT INSTABILITY OF PARCELS FROM WHICH A REVISED (LOWER) CLOUD TOP IS DETERMINED TO BE AT THE HIGHEST LEVEL OF POSITIVE BUOYANCY.

- THE LATENT HEAT OF VAPORIZATION USED TO CALCULATE EQUIVALENT POTENTIAL TEMPERATURES DURING MODEL INTEGRATION IS MADE TO BE CONSISTENT WITH THE VALUE USED IN GENERATING THE INITIAL LOOKUP TABLES._

- THE FIRST-GUESS REFERENCE TEMPERATURES IN THE UPPER-HALF OF SHALLOW CONVECTIVE CLOUDS ARE LIMITED TO BE NO MORE THAN -1 DEGREE C COLDER THAN THE AMBIENT TEMPERATURE.

December 2006 Crisis Change

http://www.emc.ncep.noaa.gov/mmb/namchanges_dec2006/NAM_Upgrades.Nov2006.html

3c. NUMEROUS CHANGES ARE MADE TO CONVECTIVE PARAMETERIZATION (continued)

- WHEN A GRID POINT FAILS THE ENTROPY CHECK FOR DEEP CONVECTION BUT STILL HAS POSITIVE CAPE, CHANGES IN TEMPERATURE AND MOISTURE BY SHALLOW CONVECTION ARE THEN CONSIDERED AT THESE SO-CALLED SWAP POINTS. THE FIRST-GUESS ESTIMATE FOR THE TOP OF SHALLOW CONVECTION IS BASED ON THE HIGHEST LEVEL WHERE THE PARCEL REMAINS POSITIVELY BUOYANT / THIS IS MORE RESTRICTIVE THAN POSITIVE CAPE/, AND THE VERTICAL EXTENT OF SHALLOW CONVECTION IS NOT TO EXCEED 0.2 TIMES THE ATMOSPHERIC PRESSURE DEPTH /E.G., 200 HPA FOR A SURFACE PRESSURE OF 1000 HPA/. A FINAL ADJUSTMENT IS MADE TO THE TOP OF SHALLOW CONVECTION IN WHICH IT CAN EXTEND TO HIGHER ALTITUDES IF THE MEAN AMBIENT RELATIVE HUMIDITY /RH/ IN THE CLOUD LAYER EXCEEDS A THRESHOLD RH WHILE REMAINING POSITIVELY BUOYANT /I.E. CAPE GREATER THAN 0/. THE THRESHOLD RH IS BASED ON THE RH AT CLOUD BASE THAT IS CONSISTENT WITH A DEFICIT SATURATION PRESSURE OF 25 MB / USUALLY NEAR 90%/. THE MAXIMUM CLOUD TOP HEIGHT FOR SHALLOW CONVECTION IS LIMITED TO 450 HPA.

December 2006 Crisis Change

http://www.emc.ncep.noaa.gov/mmb/namchanges_dec2006/NAM_Upgrades.Nov2006.html

4. THREE CHANGES ARE MADE TO THE CLOUD MICROPHYSICS:

- DURING MELTING PRECIPITATION ICE PARTICLES ARE ASSUMED TO HAVE THE SAME MEAN DIAMETER /1 MM/ AS AT THE FREEZING LEVEL.

- TWO CHANGES INTENDED TO INCREASE THE PRESENCE OF SUPERCOOLED LIQUID WATER AND IMPROVE FORECAST PRODUCTS FOR USE IN AIRCRAFT ICING ALGORITHMS:

A. THE TEMPERATURE AT WHICH SMALL AMOUNTS OF SUPERCOOLED LIQUID WATER, IF PRESENT, ARE ASSUMED TO BE GLACIATED TO ICE WAS LOWERED FROM -30C TO -40C.

B. _THE TEMPERATURE AT WHICH ICE NUCLEATION IS ALLOWED TO OCCUR WAS LOWERED FROM -5C TO -15C BASED ON AIRCRAFT ICING OBSERVATIONS_

5. ALLOW HORIZONTAL DIFFUSION BETWEEN NEIGHBORING GRID POINTS WITH A SLOPE OF LESS THAN OR EQUAL TO 54 M / 12 KM (9X THAT IN OPERATIONAL NAM).

December 2006 Crisis Change

http://www.emc.ncep.noaa.gov/mmb/namchanges_dec2006/NAM_Upgrades.Nov2006.html

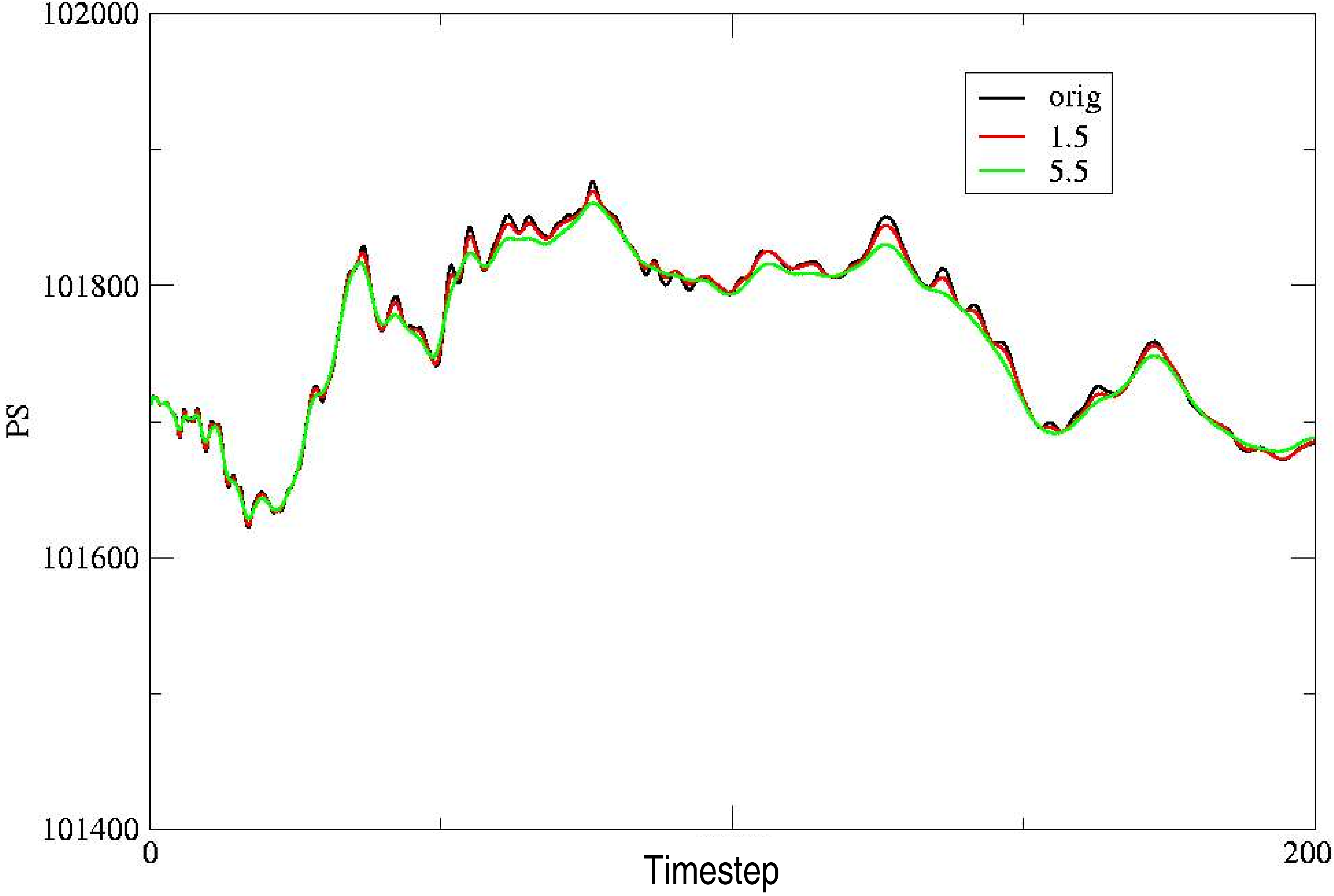
THE COMBINED IMPACT OF THESE CHANGES HAS LED TO:

- SLIGHT IMPROVEMENT IN NAM QPF SCORES,
- A 5-10% REDUCTION IN NAM HEIGHT, TEMPERATURE AND VECTOR WIND ROOT-MEAN-SQUARE ERRORS COMPARED TO RADIOSONDES /POSITIVE IMPACTS INCREASE WITH FORECAST RANGE/,
- A SIGNIFICANT REDUCTION IN THE FALSE ALARM RATE FOR TROPICAL STORMS.
- THE NUMERICAL INSTABILITY OBSERVED OFF NEWFOUNDLAND IN OPS NAM RUNS FROM 1-4 DECEMBER WAS ELIMINATED BY THESE CHANGES.

Divergence Damping Change Motivation

- Noisy analysis increments in NDAS
- Relatively frequent update every 3 hours
  - We want even more frequent not less
- Insufficient time for model to adjust
- Lack of Digital Filter Initialization in NDAS
  - DFI not easy to include quickly in WRF
- External mode gravity waves most likely ramification of the imbalance
  - Therefore, increase their damping during assimilation

Impact of change to divergence damping on surface pressure trace

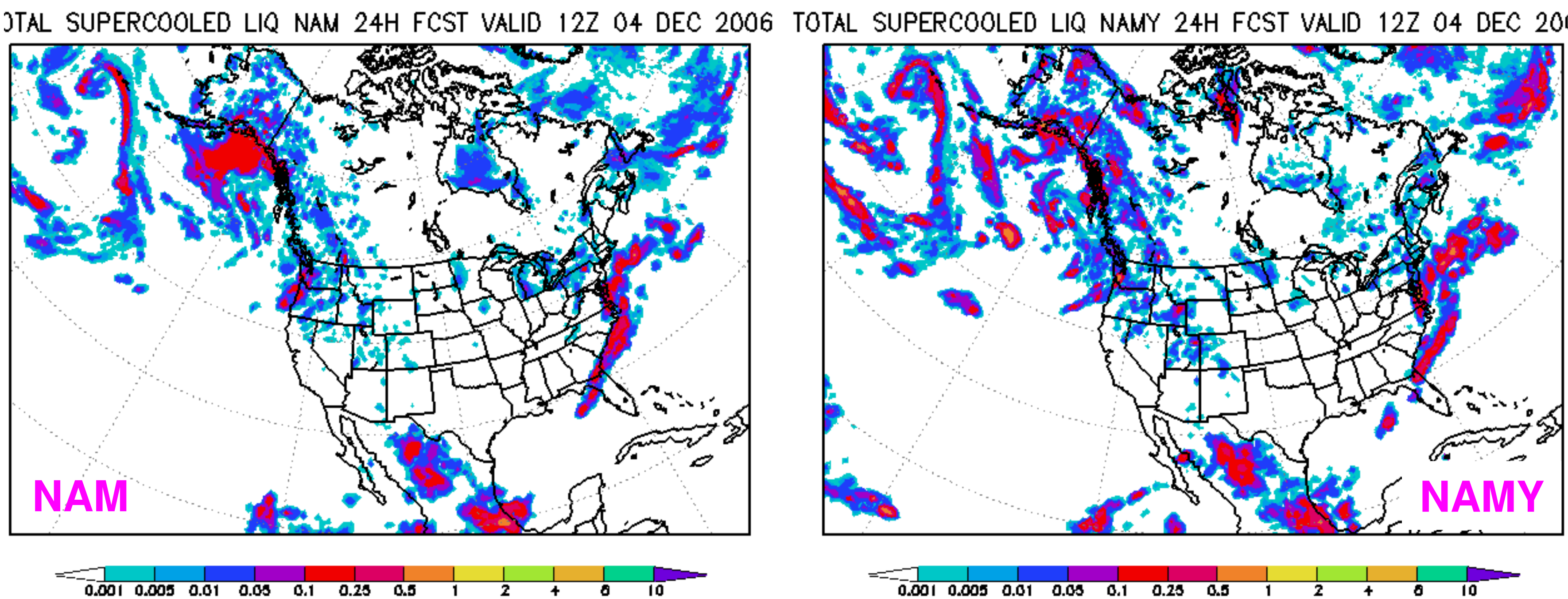


Microphysics changes

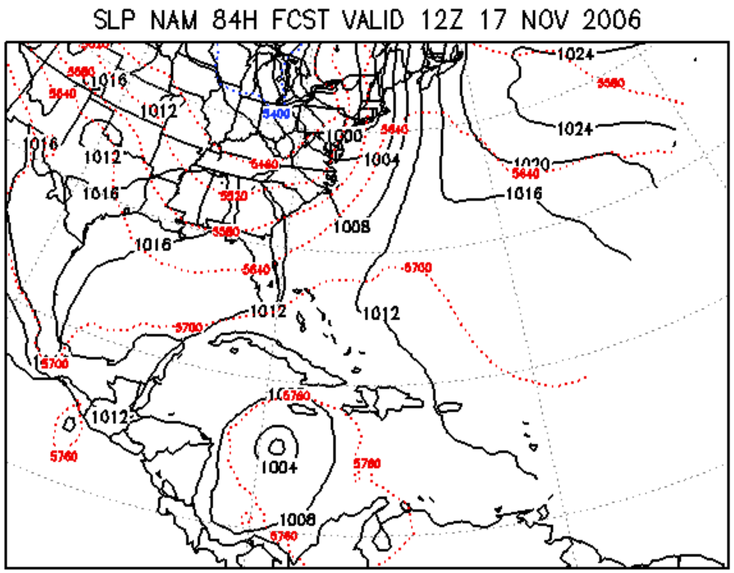
- **Precipitation ice particles are assumed to have a fixed mean diameter (1 mm) during melting. Should reduce rates of melting (and cooling).**

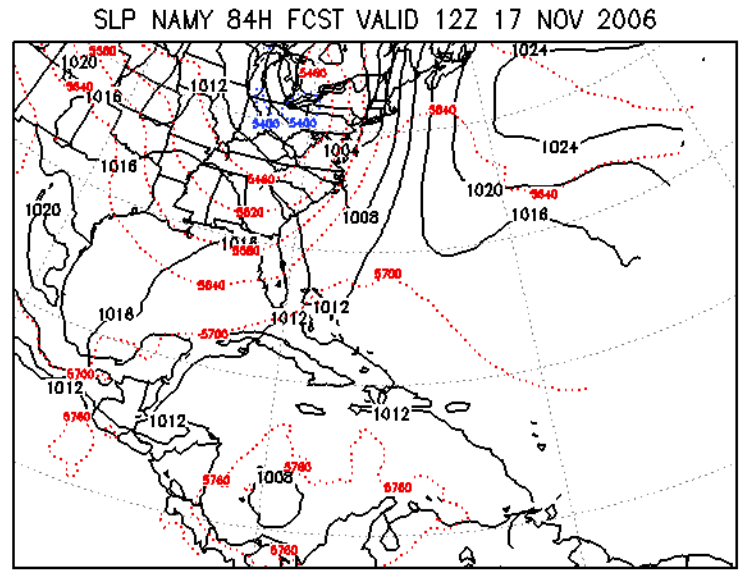
- **Changes to produce more supercooled liquid water:**
  1) complete glaciation at -40°C (was -30°C);
  2) onset of ice nucleation at -15°C (was -5°C) based on aircraft observations

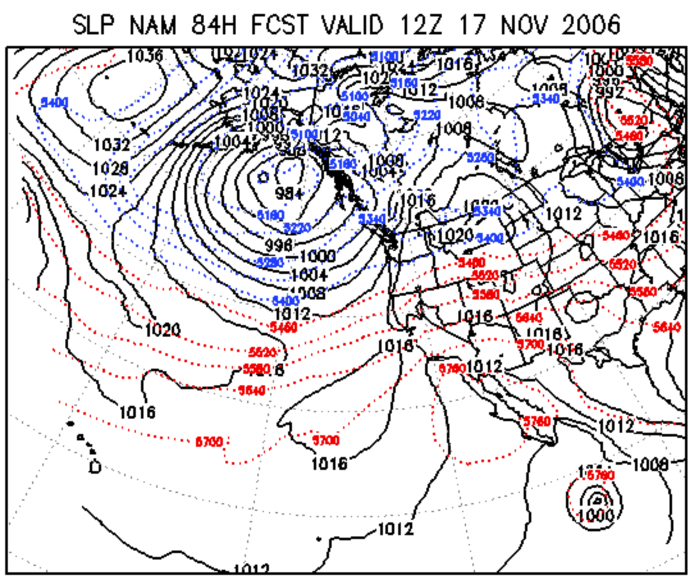
24-h column-integrated supercooled (T<0°C) liquid water (mm)

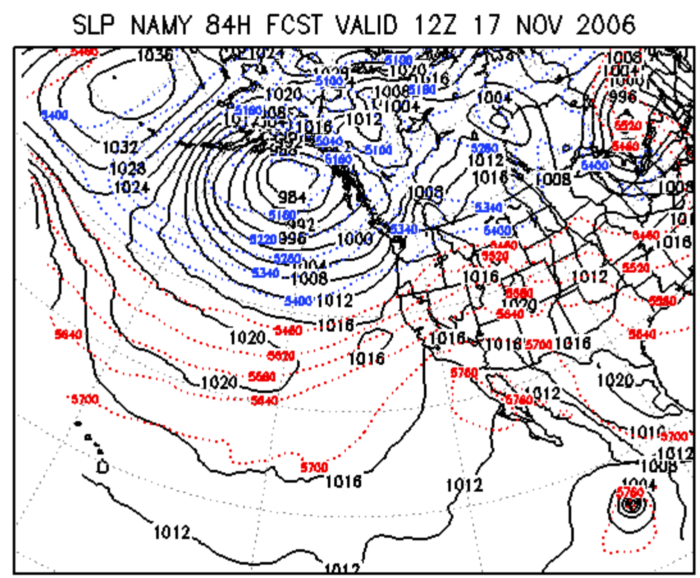


Unobserved TC eliminated while Observed storm (Sergio) retained









N
C
E
P

Implementation Brief: Real-Time Mesoscale Analysis (RTMA)

Geoff.DiMego@noaa.gov

301-763-8000 ext7221

9 August 2006

Where the Nation's climate and weather services begin

RTMA Configuration

- Temperature & dew point at 2 m & wind at 10 m
  - RUC (13 km) 1 hr forecast is downscaled by GSD to 5 km NDFD grid
  - NCEP's 2DVar analysis uses ALL surface observations to update downscaled RUC first-guess
  - NCEP's 2DVar produces estimate of analysis uncertainty
- Precipitation – NCEP Stage II analysis
- Sky cover – NESDIS GOES sounder "Effective Cloud Amount"

Precipitation RTMA

- *Ying Lin's existing Stage 2 National Precipitation Analysis hourly product*
  - *Timely ~35min after each hour*
  - *High resolution ~4 km HRAP grid*
- *Interpolate Stage 2 product to 5 km NDFD grid to create the RTMA Precipitation analysis product*
- *Since April 19, 2005 http://wwwt.emc.ncep.noaa.gov/mmb/*
- *Became operational 13Z 28 June 2006*

Mesonet Issues

- Mesonets comprise majority of obs but they are not as good as other conventional sfc ob sources
  - No mesonet winds used in current RUC (or NAM) due to slow wind bias – must rely on GSD "Uselist"
- Data volumes arriving at NCEP from MADIS are deficient to run analysis in time for targeted 30 minute delivery
- Temporarily moved ob dump to H+30 to get sufficient obs – leads to delivery at H+42
- This delay caused implementation to be declared "conditional" until MADIS can remove latency with server upgrade (due in 2007)

RTMA Evaluation Website

- http://www.emc.ncep.noaa.gov/mmb/rtma/
- Established 24 Jan. 2006 by Geoff Manikin
  - 7 geographical sub-regions displayed: NE, DC, FL, MW, TX, NW and SW
  - 3 analysis field displays: 2 m Temperature, 2 m Dew Point and 10 m Wind
  - 4 analysis increment displays: 2 m Temp, 2 m Dew Point, 10 m Wind Speed and 10 m Vector Wind
- The IFPS Science Steering Team (ISST) has coordinated the distribution of the parallel datasets to the field and is conducting a field evaluation similar to that of the DGEX implementation
- Western region site http://www.wrh.noaa.gov/wrh/rtma/

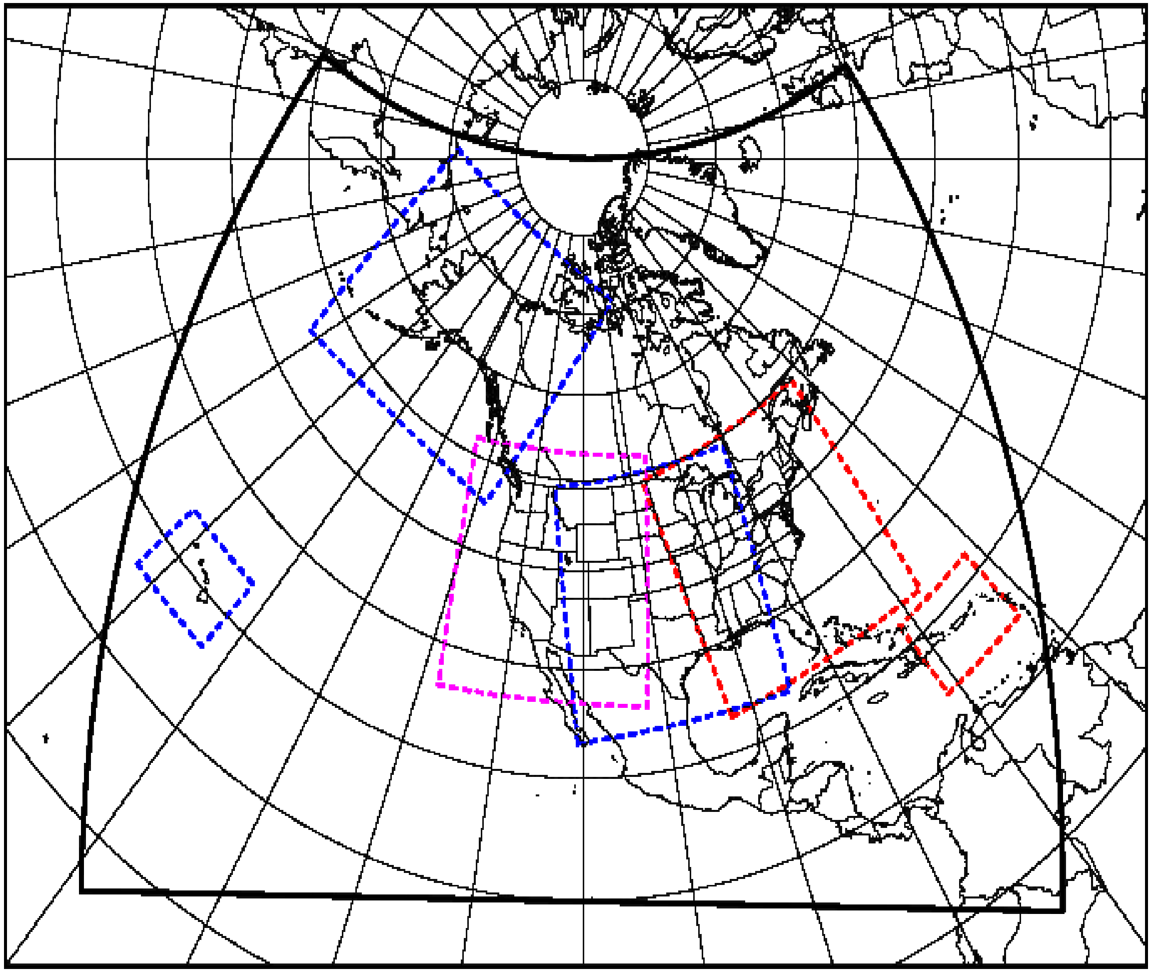
Evolution of HiResWindow Runs: SPC Requirements (Matt Pyle Run)

- Twice per runs at 00z and 12z
- Expanded (E Central) domain
- 4 km resolution

HiResWindow Fixed-Domain Nested Runs

28 June 2005 Become Explicit WRF Runs

- FOUR routine runs made at the same time every day
- 00Z : Alaska & Hawaii
- 06Z : Western & Puerto Rico
- 12Z : Central & Hawaii
- 18Z : Eastern & Puerto Rico
- Everyone gets daily high resolution runs ***if & only if*** hurricane runs are not needed



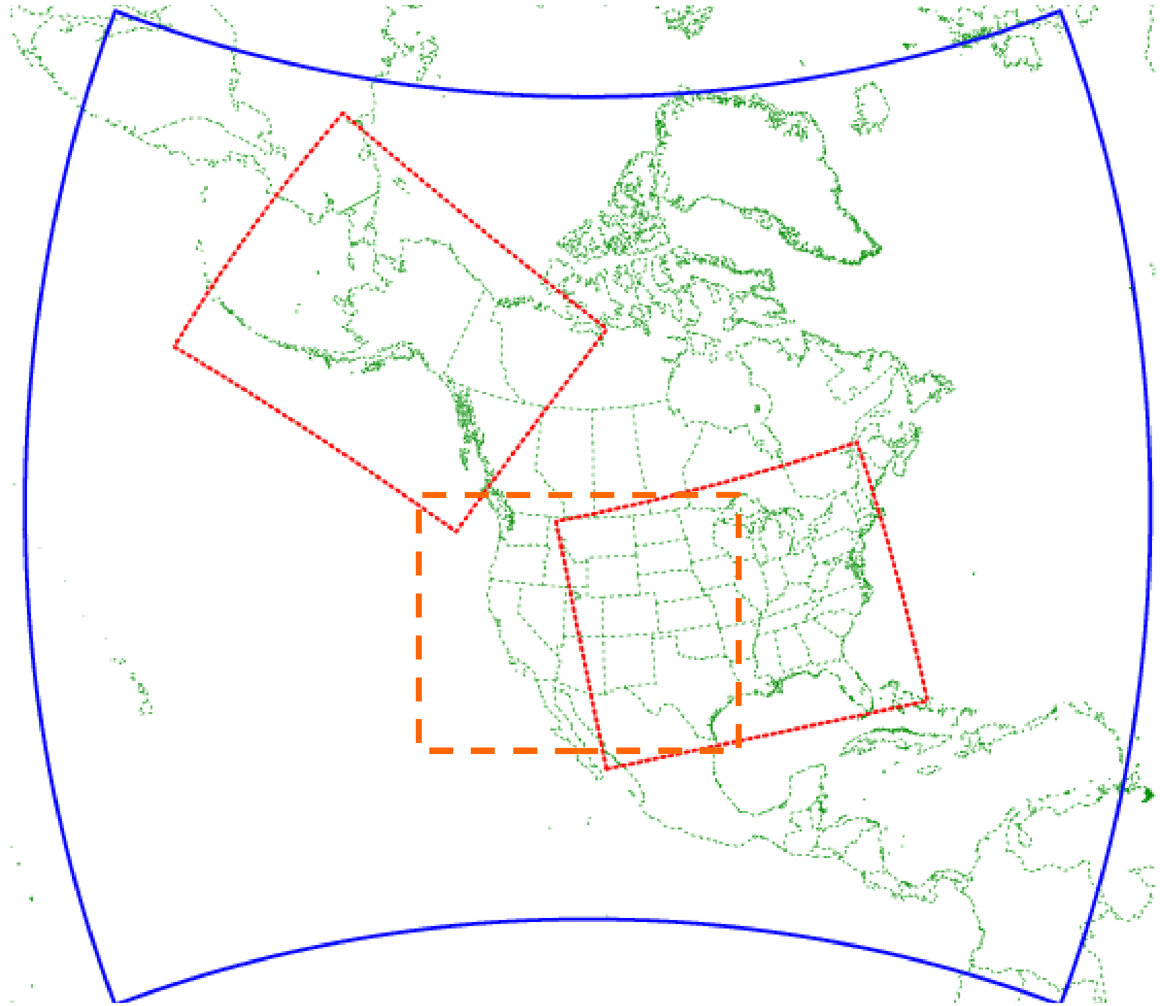
http://www.emc.ncep.noaa.gov/mmb/mmbpll/nestpage/

Alaska domain is smaller than depicted

HiResWindow Fixed-Domain Nested Runs

Proposed ~4km run Configuration

- FOUR routine runs made at the same time every day
- 00Z : ECentral & Hawaii
- 06Z : Alaska & Puerto Rico
- 12Z : ECentral & Hawaii
- 18Z : WCentral & Puerto Rico
- Everyone gets daily high resolution runs ***if & only if*** hurricane runs are not needed

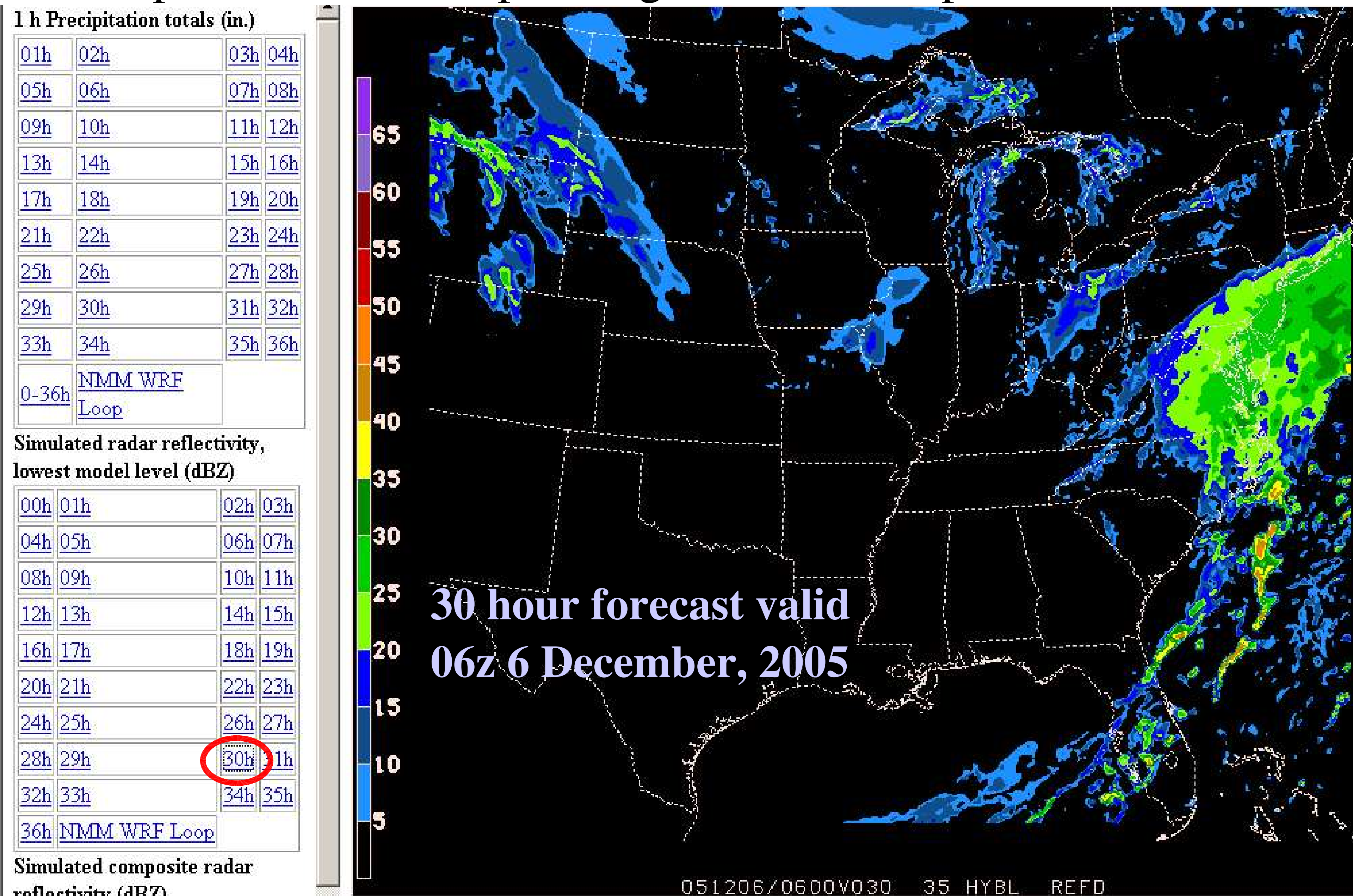


http://www.emc.ncep.noaa.gov/mmb/mmbpll/nestpage/

Alaska domain is smaller than depicted

Pyle Webpage Now Displaying Simulated Reflectivity

http://www.emc.ncep.noaa.gov/mmb/mmbpll/cent4km/v2/



NCEP Air Quality Forecast System Progress and Plans

Jeff McQueen, Pius Lee, Marina Tsildulko, Geoff Manikin
Sarah Lu, Ho-Chun Huang, Bert Katz and You-hua Tang

- Guidance Interim Smoke Product

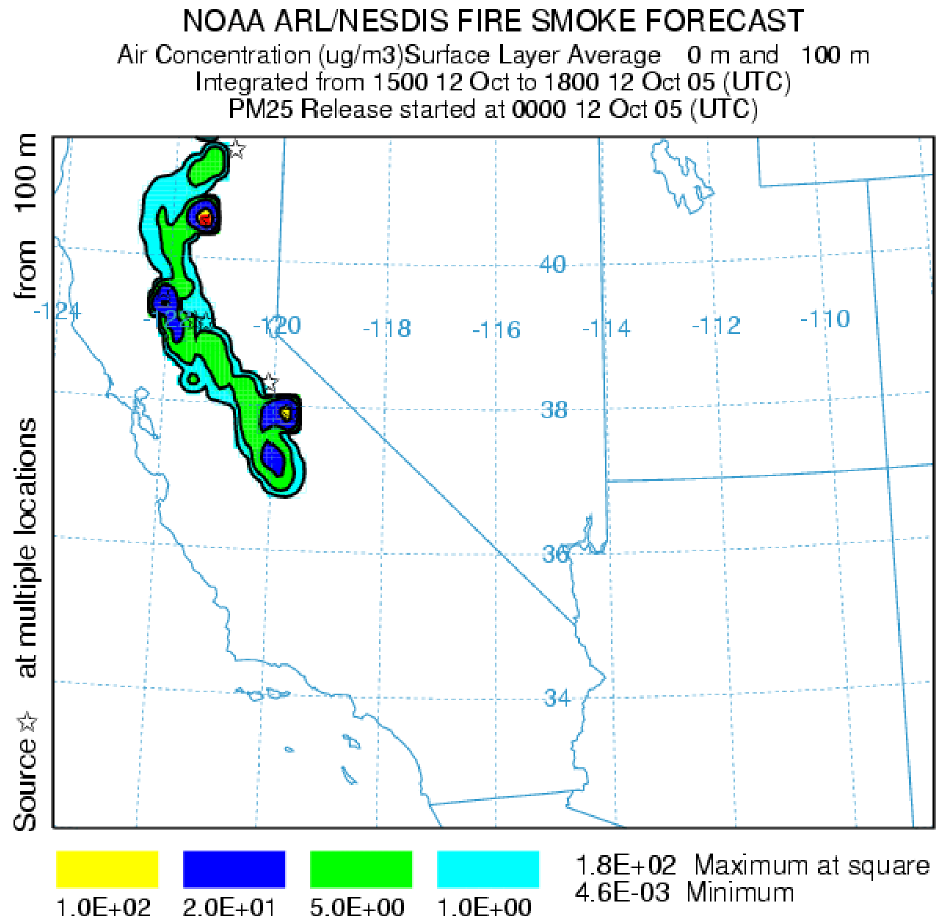
Fire locations from NESDIS

HYSPLIT (Lagrangian model) uses NAM winds to transport smoke

Interim Smoke System creates National Product

Historical smoke distribution

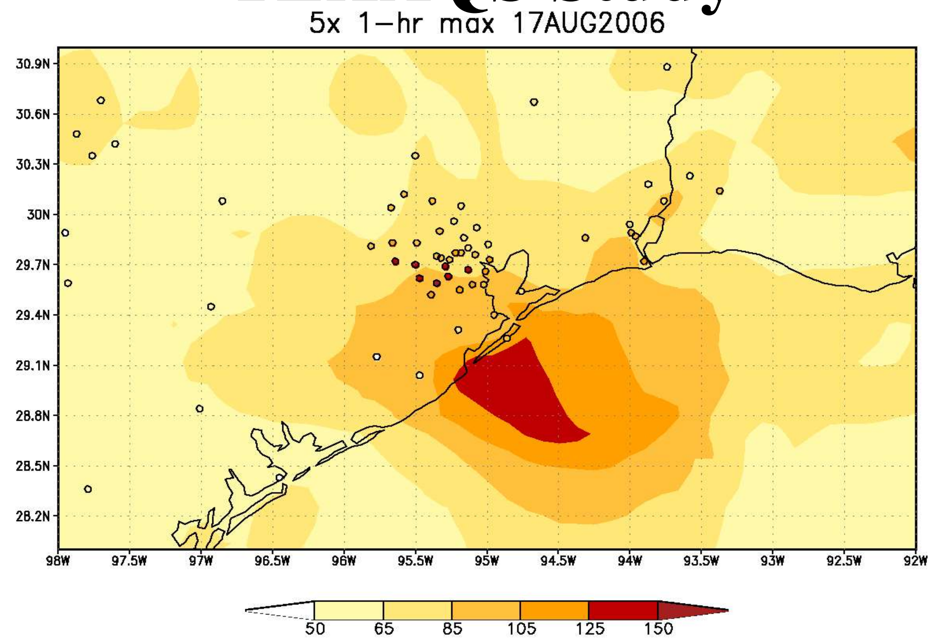
Smoke from new fires



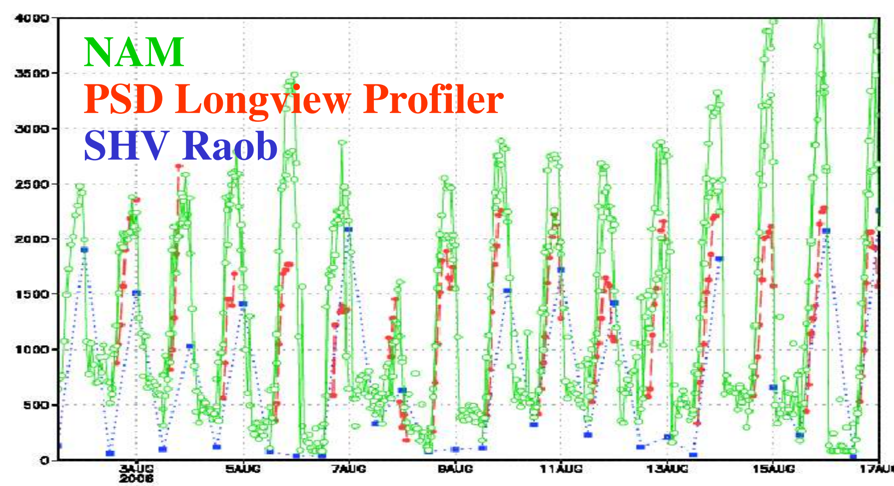
2006 Developments

- WRF Transition
  - Improved tight vertical coupling
  - Continued convective mixing & vertical layering tests
  - Continued lateral boundary condition tests
- CMAQ Improvements
  - Optimized Advection scheme
  - Emissions upgraded for 2006
- AQF system retrospective & Real-time testing
  - July 2005 with experimental CONUS configuration
- Real-time Verification
  - Spatial map comparisons to observations (03 & PBL hgt)
  - Inclusion of AIRNOW PM 2.5 observations
  - Use of ACARS, ESRL Profilers for PBL hgt verification
  - Inclusion of NESDIS GASP AOD products
- Improved Analyses & Visualizations
  - Focus group, TEXAQS06 & SHENAIR projects
  - Vertical gas-phase and aerosol chemistry profiles

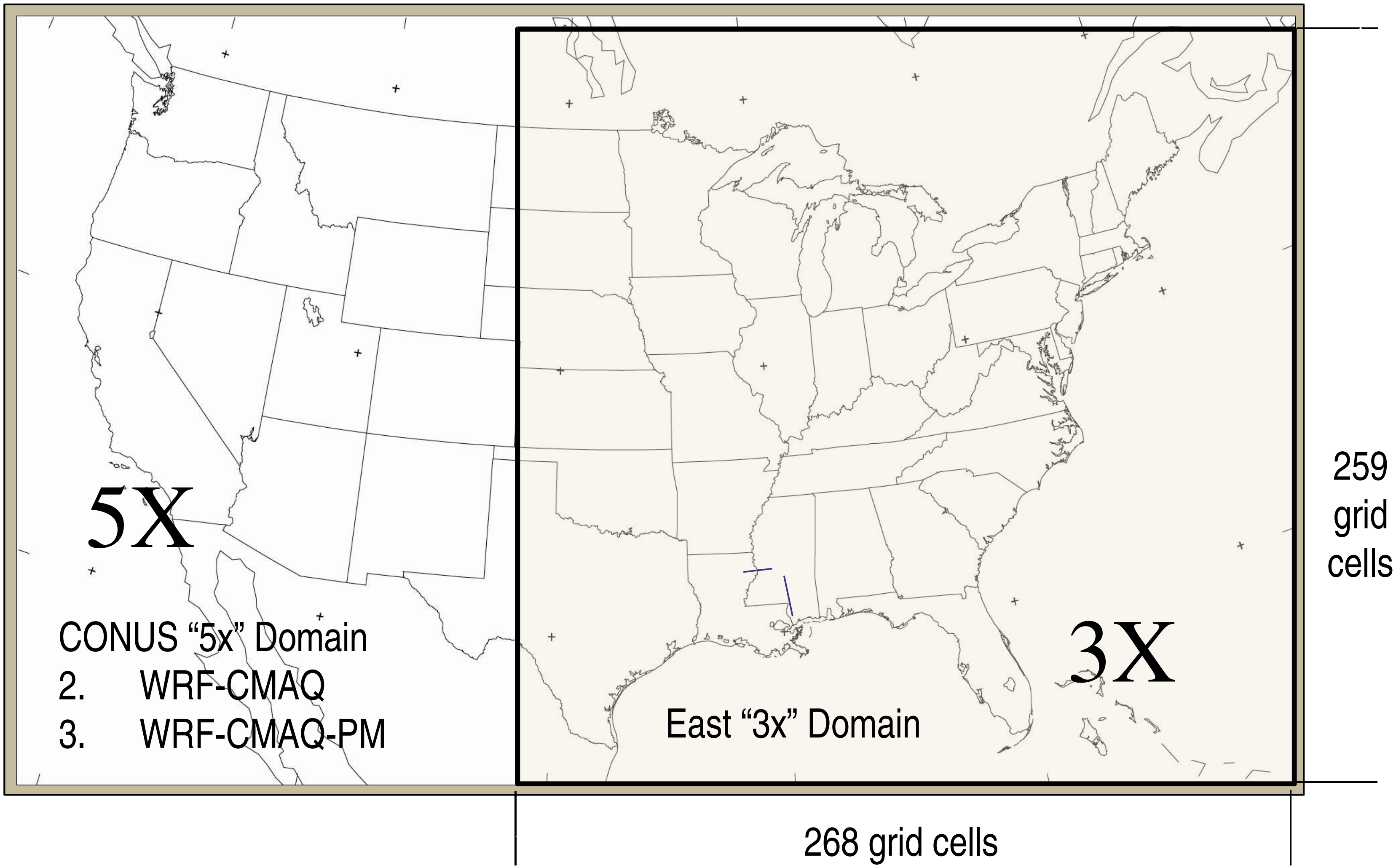
TEXAQS Study



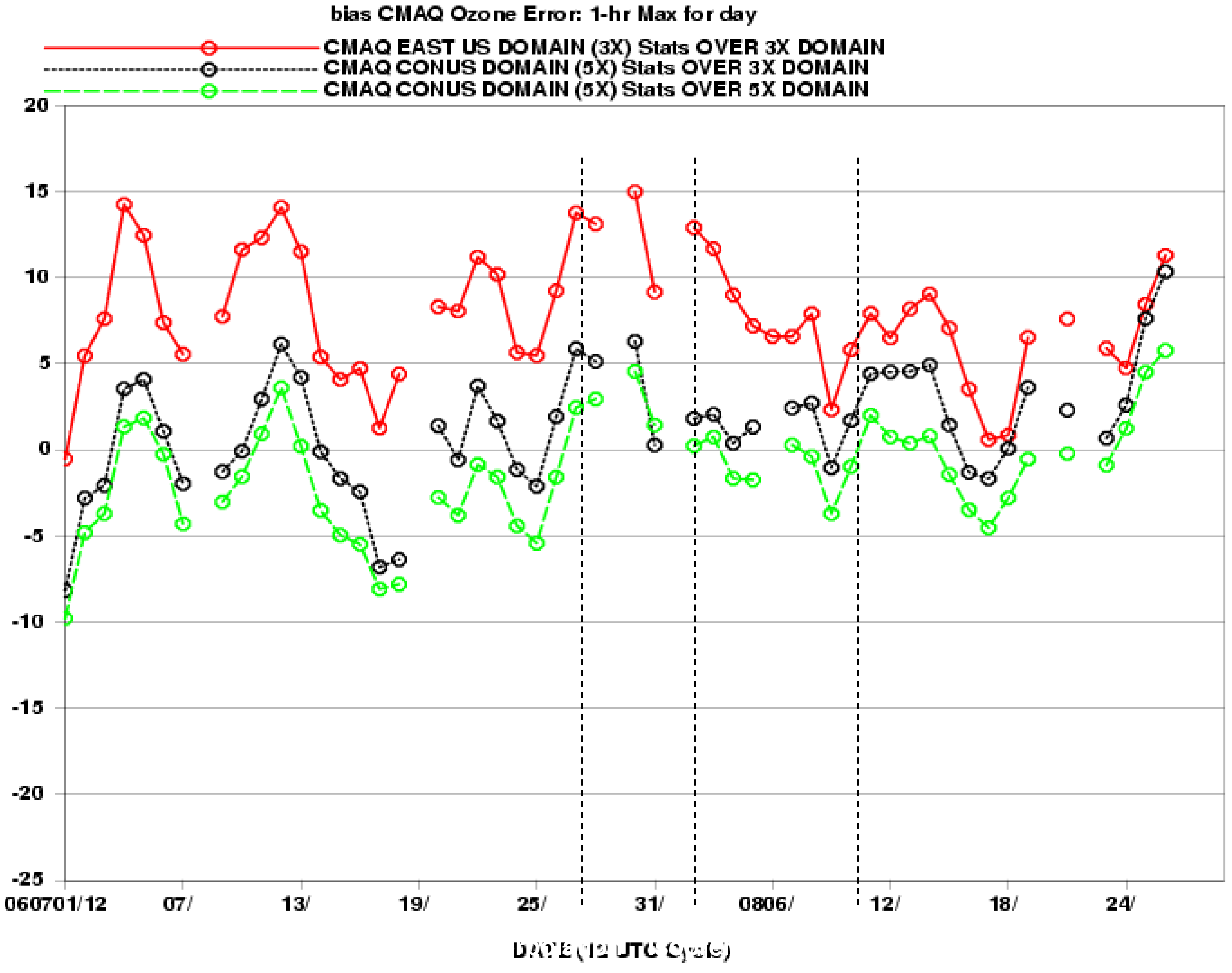
NAM PBL evaluation using TEXAQS profilers



Forecast Domains (2006)



Summer 2006 Performance



2007 Regional AQ Plans

- WRF Coupling
  - Common horizontal E grid coordinate
  - Continued convective & PBL mixing & vertical layering tests
  - Continued lateral boundary condition tests

- AQF system retrospective & Real-time testing
  - July 29-Aug. 6, 2006 with experimental CONUS configuration
  - Can WRF Launcher be used (no 3DVAR, ½ domain, 50 mb top)?

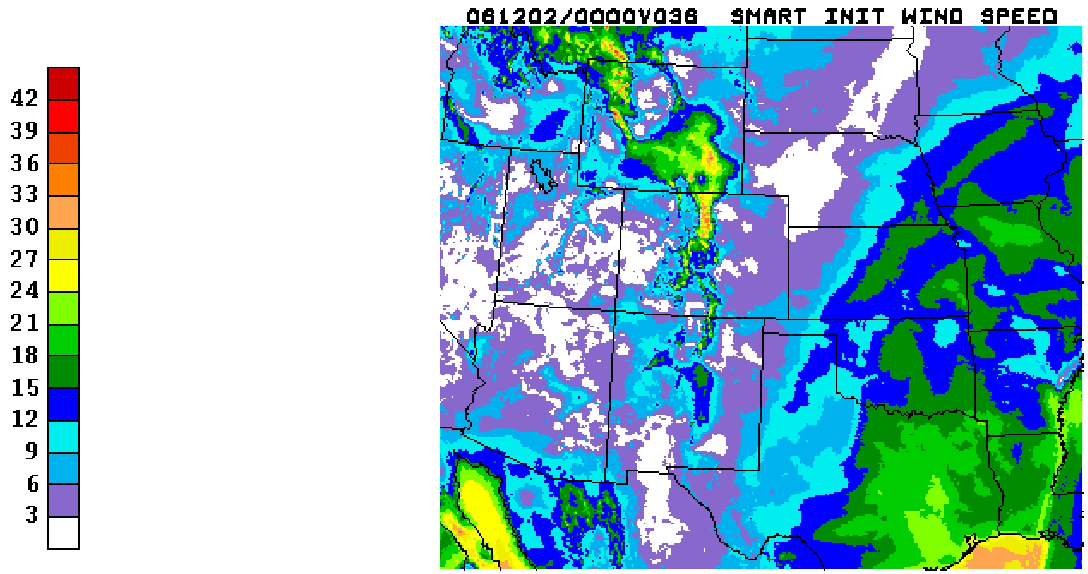
- Real-time Verification
  - Inclusion of AIRNOW PM 2.5 observations
  - Use of ACARS, ESRL Profilers for PBL height verification
  - Inclusion of NESDIS GASP AOD products

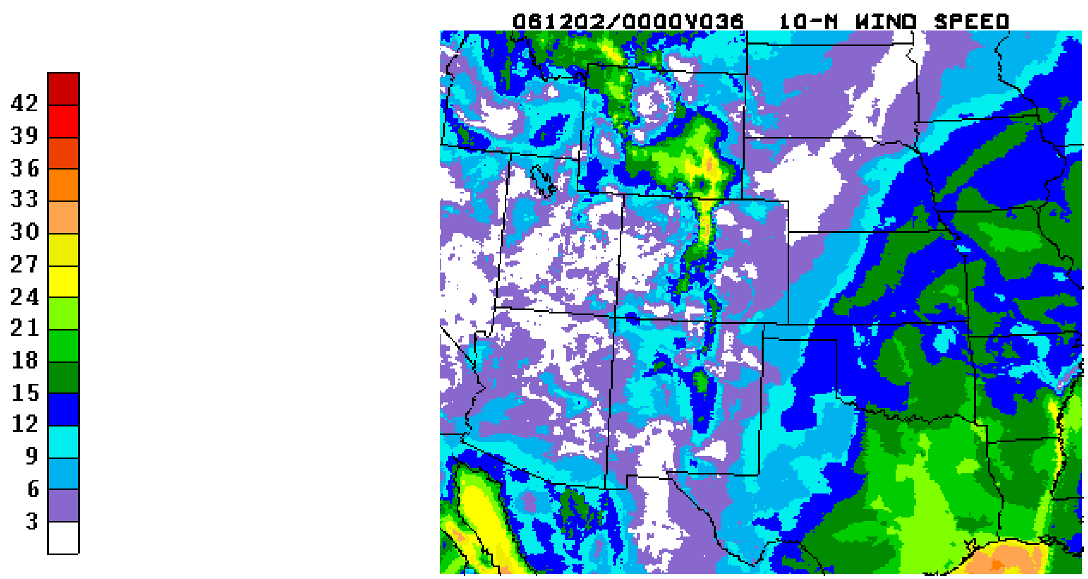
- Improved Analyses & Visualizations
  - TEXAQS06, Central California
  - Improved web page visualizations
  - Ozonesonde comparisons

Downscaling Numerical Guidance
Geoff Manikin

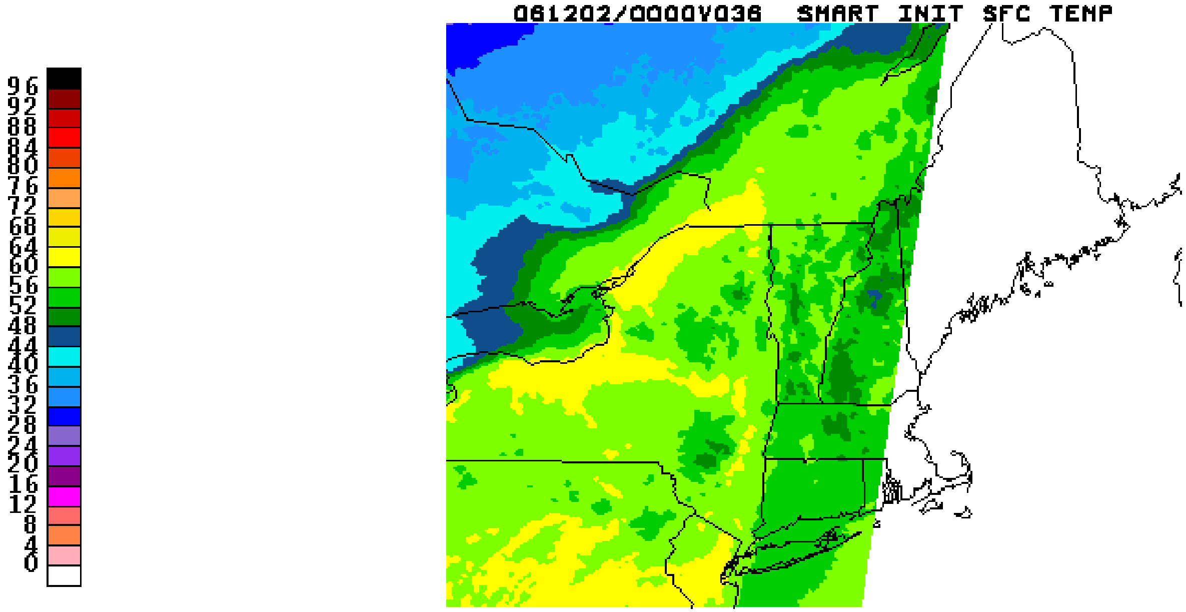
- Started with SMARTINIT python code
- Combined with RUC downscaling code
- Using computational grids of the NAM
- Will output in GRIB2 in GRIB2 units
- AWIPS ingest will convert to AWIPS units when converting to NetCDF
- Work nearly complete

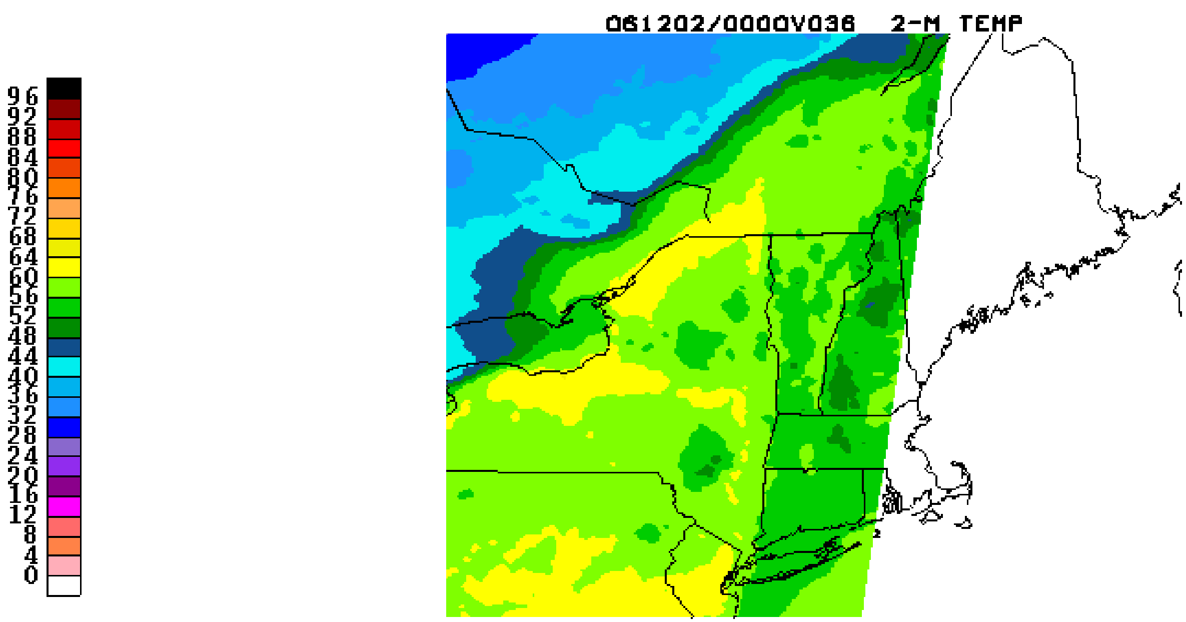
Good wind example (downscaled vs. 10 meter, showing increased speeds over higher terrain)



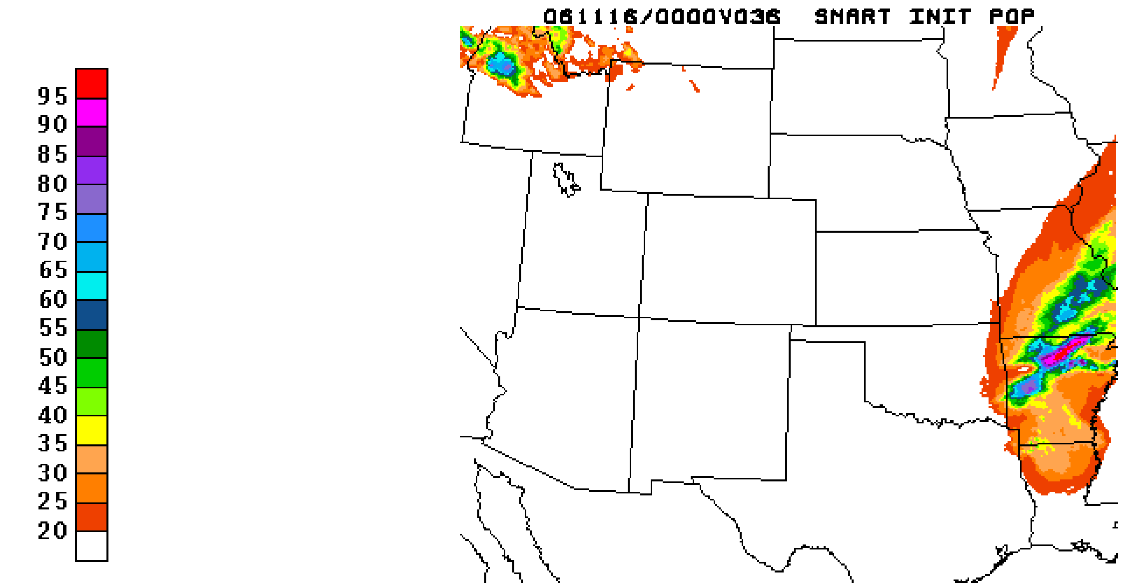


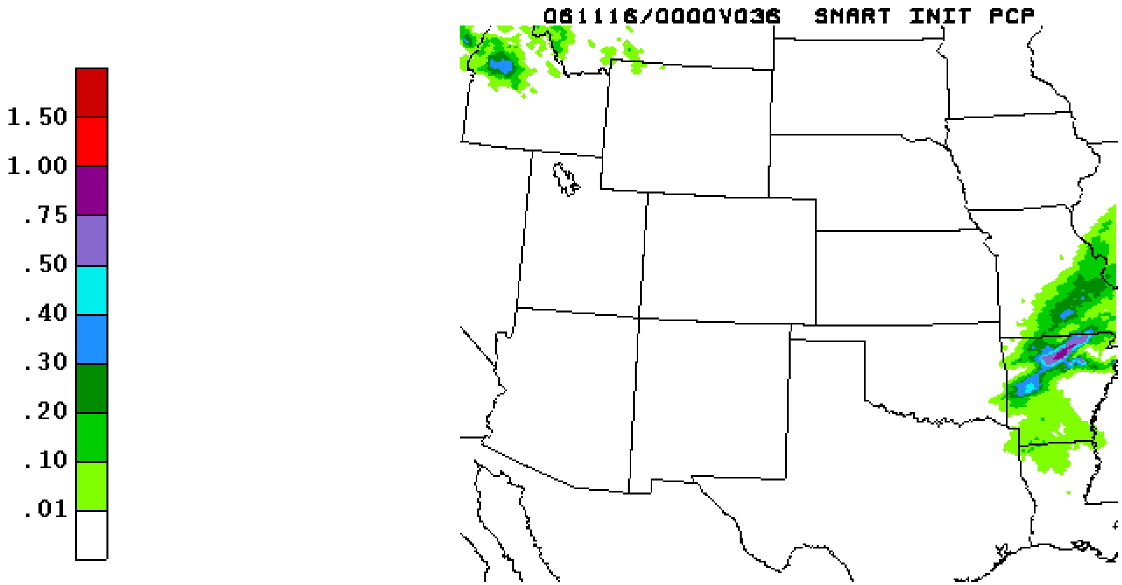
Temperature (downscaled vs. 2-m)



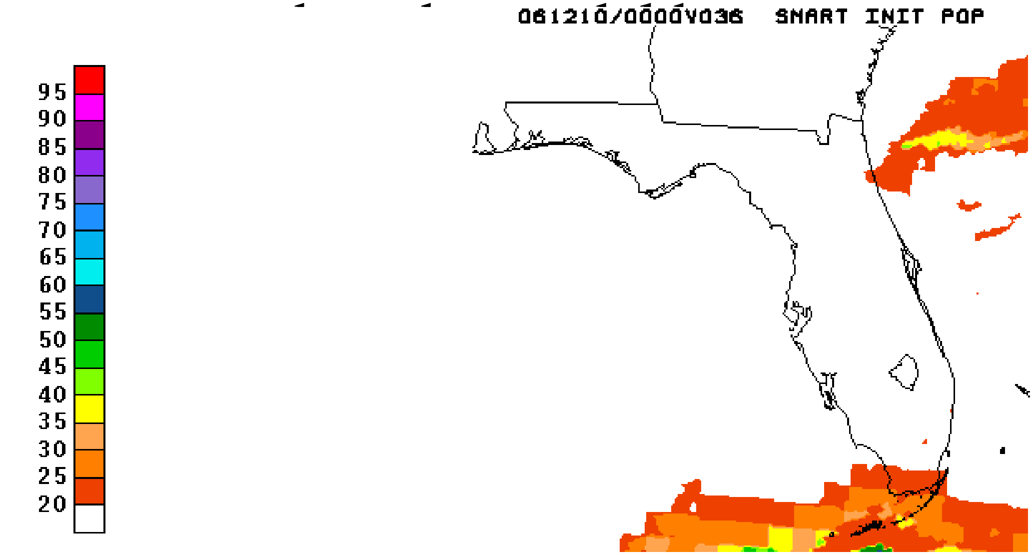


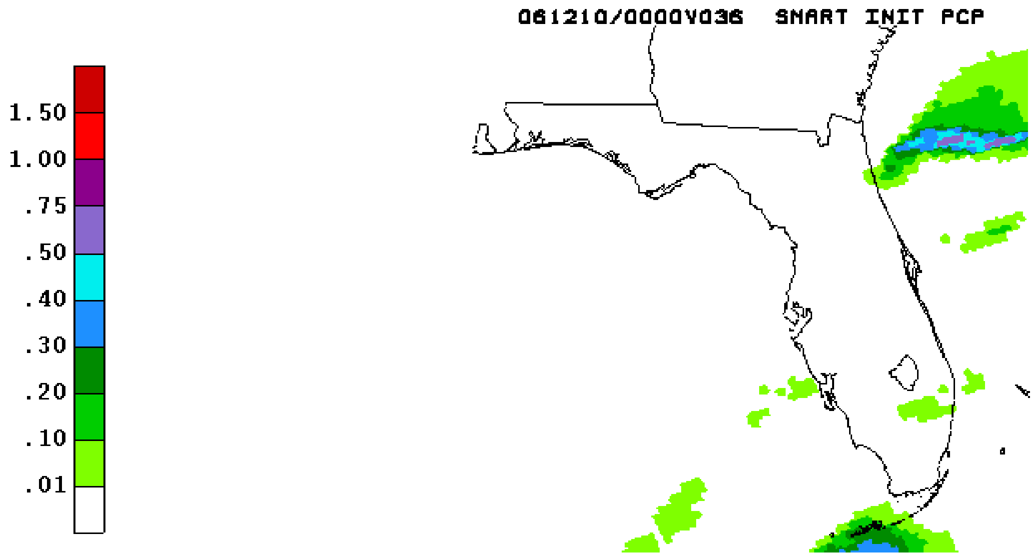
This shows flawed POP methodology from smartinit which assigns high pops to any area where the NAM has high qpf





SREF precip prob being incorporated. No great examples since last week was very dry, but this example shows how Manikin's methodology doesn't automatically assign higher





Downscaling Method & Application

- Truth = High Resolution Analysis = RTMA
  - operational North American Real-Time Mesoscale Analysis (RTMA)
    - 5x5 km National Digital Forecast Database (NDFD) grid (e.g. G. DiMego et al.)
    - 4 variables available: surface pressure, T2m, 10m U and V
  - other data can also be used
- Downscaling Method: apply decay averaging algorithm

downscaling vector = (1-*w*) * prior d.v. + *w* * (GDAS – RTMA)

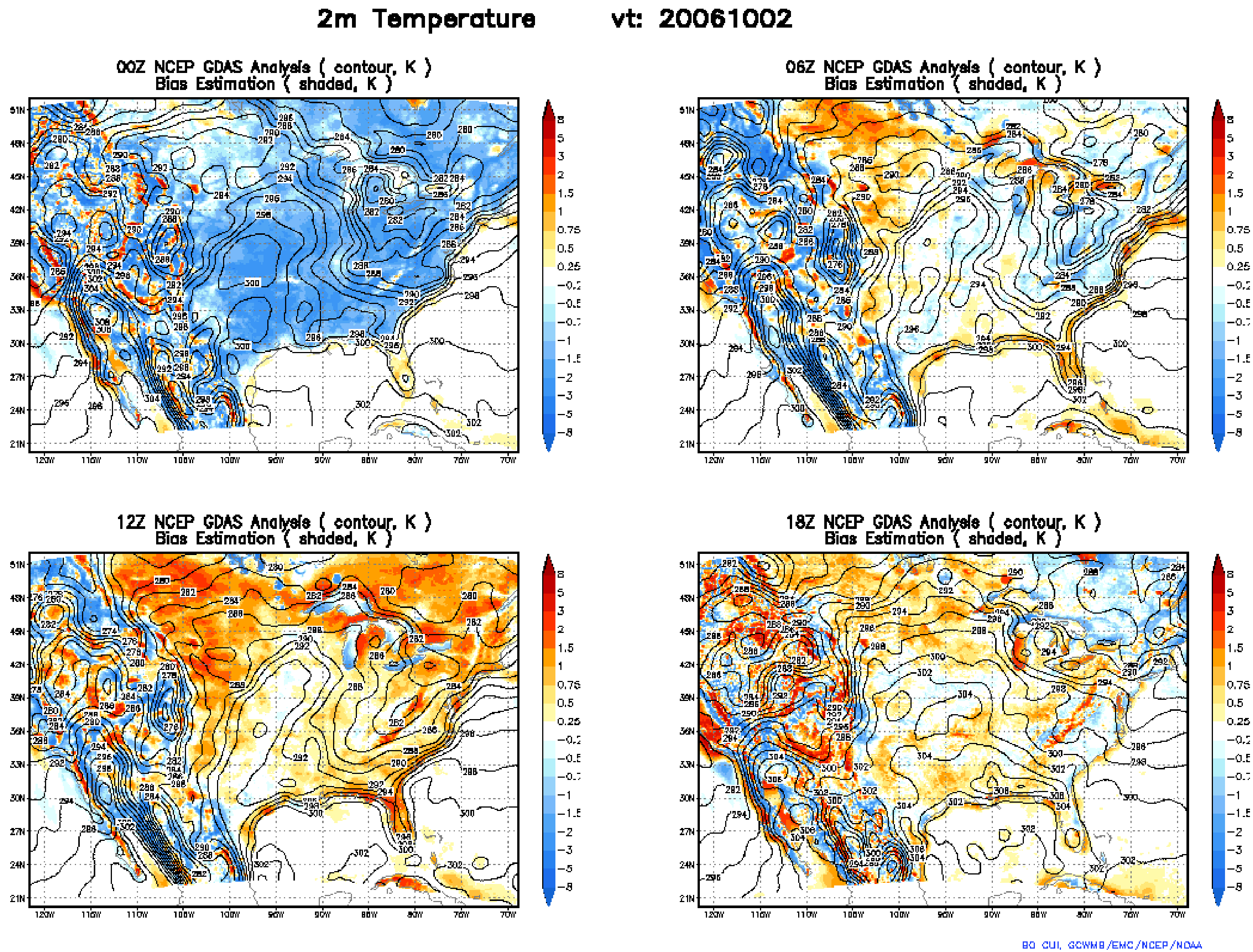
- ➢ *four cycles, individual grid point, d.v. = downscaling vector*
- ➢ *GDAS analysis and forecast interpolated to RTMA grids*
- ➢ *regime (not flow) dependent*

- Downscaling Process

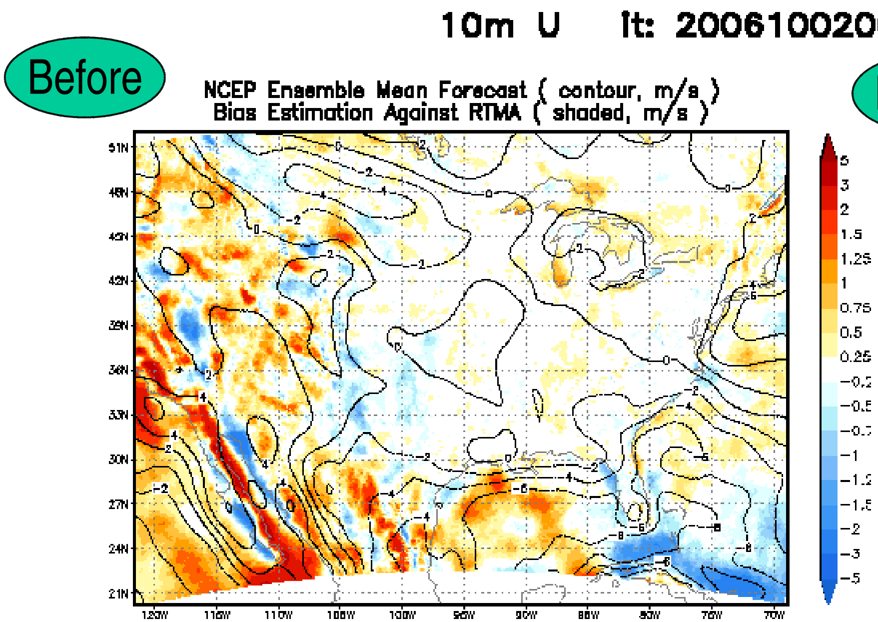
downscaled forecast = bias-corrected forecast – downscaling vector

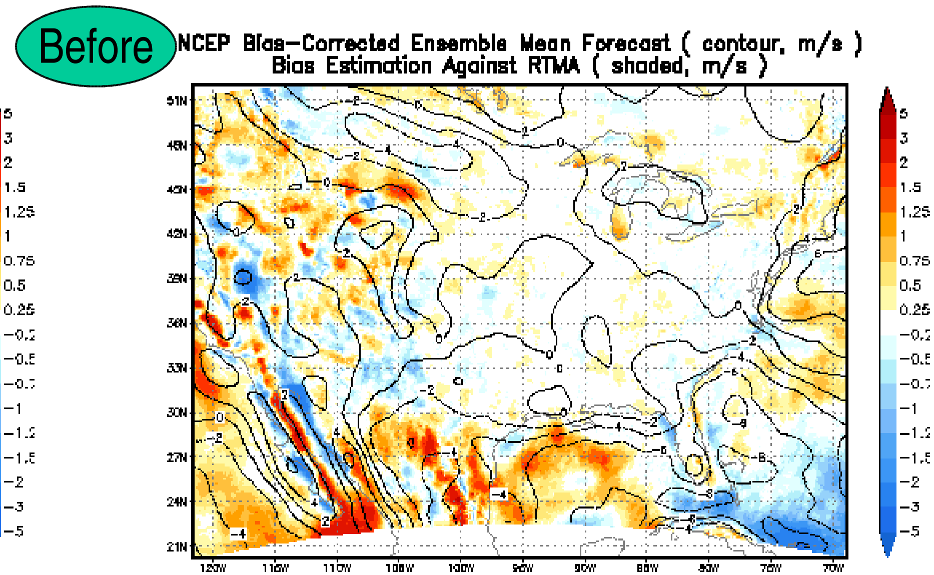
- Application
  - off-line experiments starting from 08/11/2006, different decaying weights 2%, 5%,10%
  - baseline for evaluating other sophisticated flow dependent downscaling methods

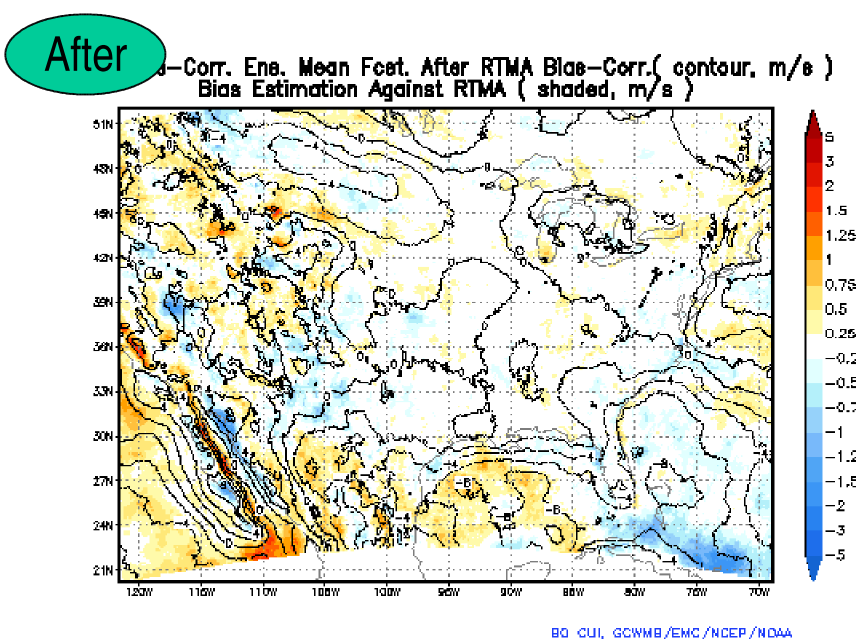
GDAS Analysis & Downscaling Vector



Ensemble Mean Forecast & Bias Before/After RTMA Downscaling







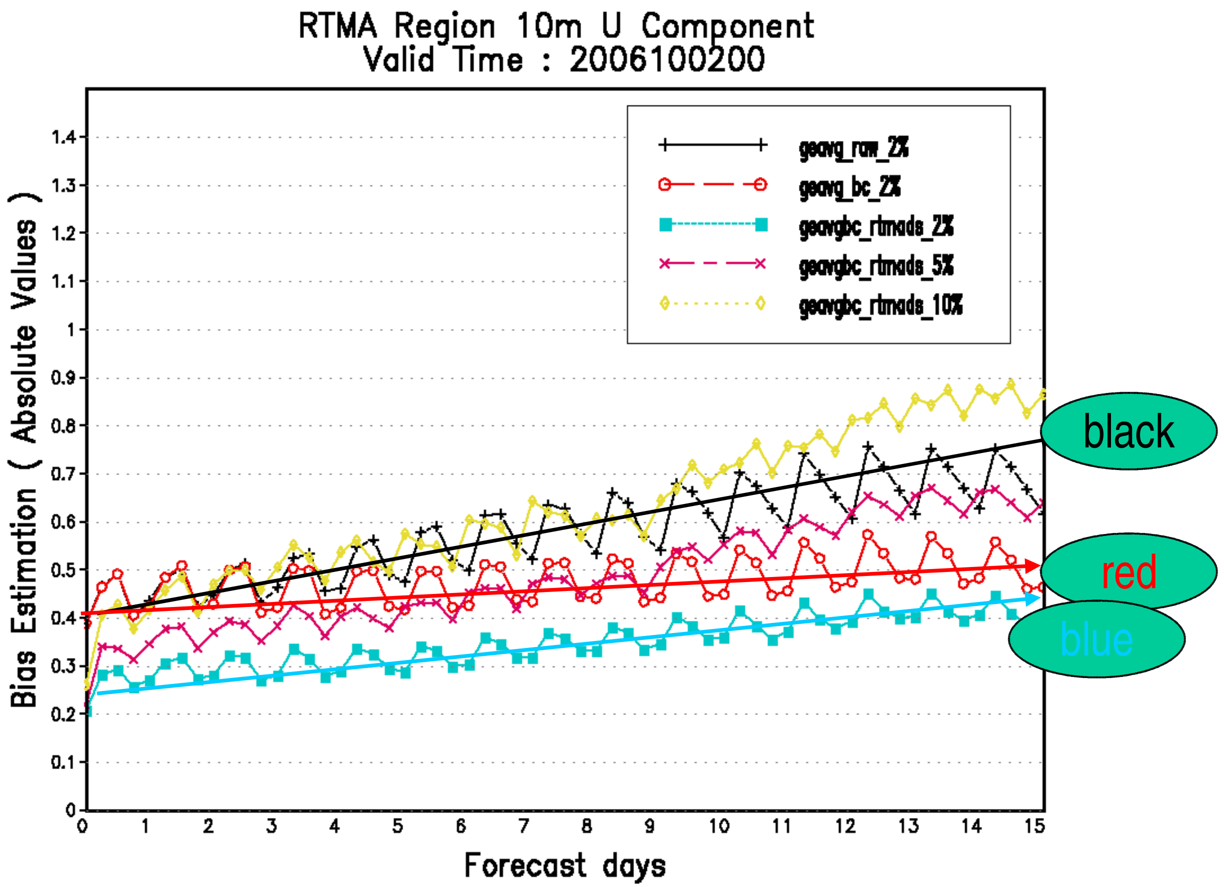
2% experiments

- Left top: operational ens. mean and its bias
- Right top: bias corrected ens. mean and its bias
- Left bottom: bias corrected ens. mean after downscaling and its bias left toward RTMA

After Downscaling

- More detailed forecast information
- Bias reduced, especially high topography areas

Accumulated Bias Before/After RTMA Downscaling



Black- operational ensemble mean, 2%

Pink- bias corrected ens. mean after downscaling, 5%

Red- NAEFS bias corrected ensemble mean, 2%

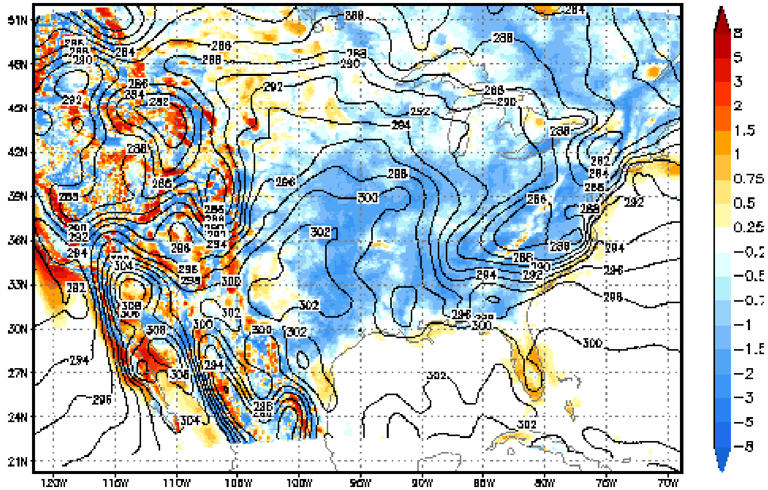
Blue-bias corrected ens. mean after downscaling, 2%

Yellow-bias corrected ens. mean after downscaling, 10%

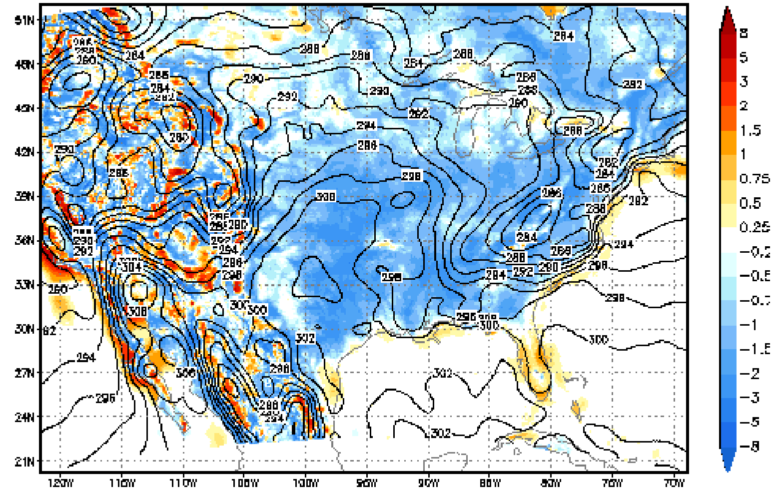
Ensemble Mean Forecast & Bias Before/After RTMA Downscaling

2m Temperature   It: 2006100200   (24 h)

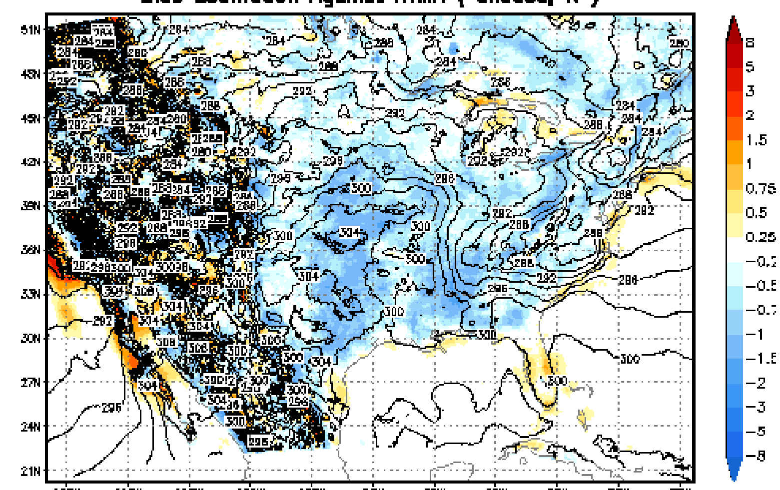
NCEP Ensemble Mean Forecast (contour, K)
Bias Estimation Against RTMA (shaded, K)



NCEP Bias-Corrected Ensemble Mean Forecast (contour, K)
Bias Estimation Against RTMA (shaded, K)



NCEP Bias-Corr. Ens. Mean Fcst. After RTMA Bias-Corr.(contour, K)
Bias Estimation Against RTMA (shaded, K)

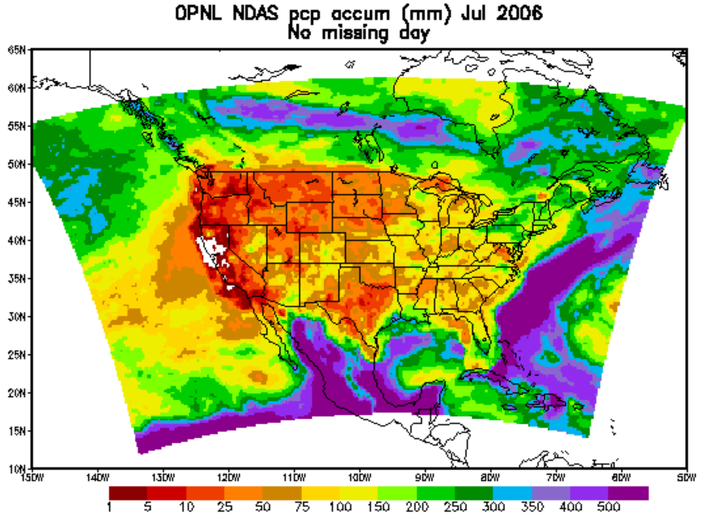


BO CUI, GCWMB/EMC/NCEP/NOAA

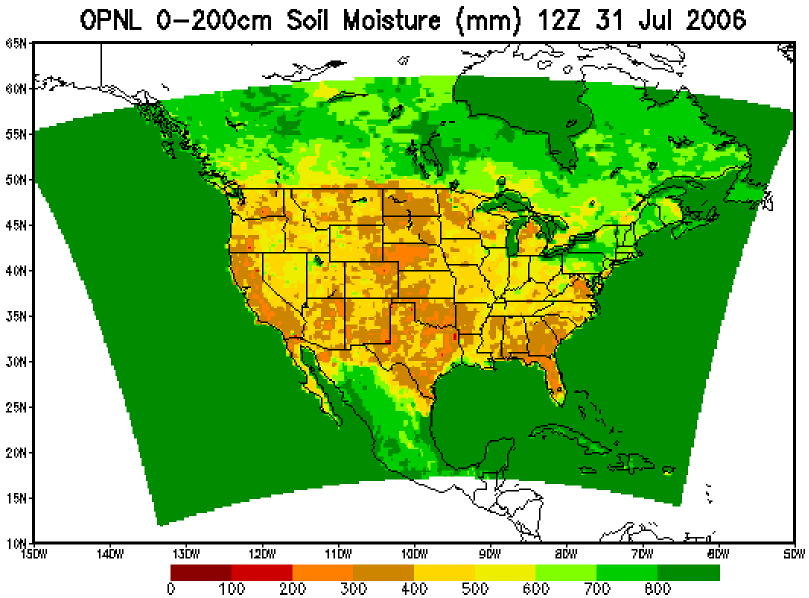
Assimilation Plans:
Precipitation Driver for Soil Moisture

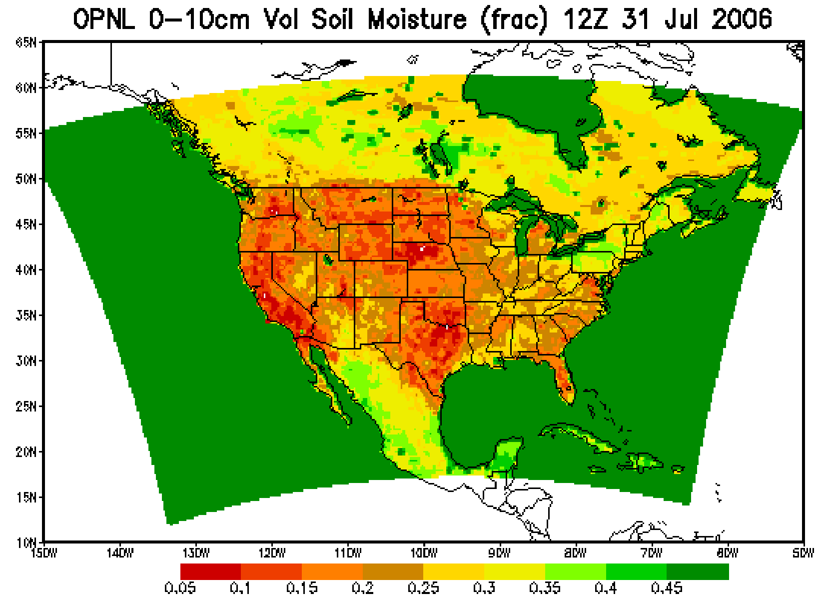
In WRF/NMM, hourly precipitation analysis (a merged Stage II/Stage IV hourly product, after adjusting for bias using long-term budget history array) is used as driver for soil moisture.

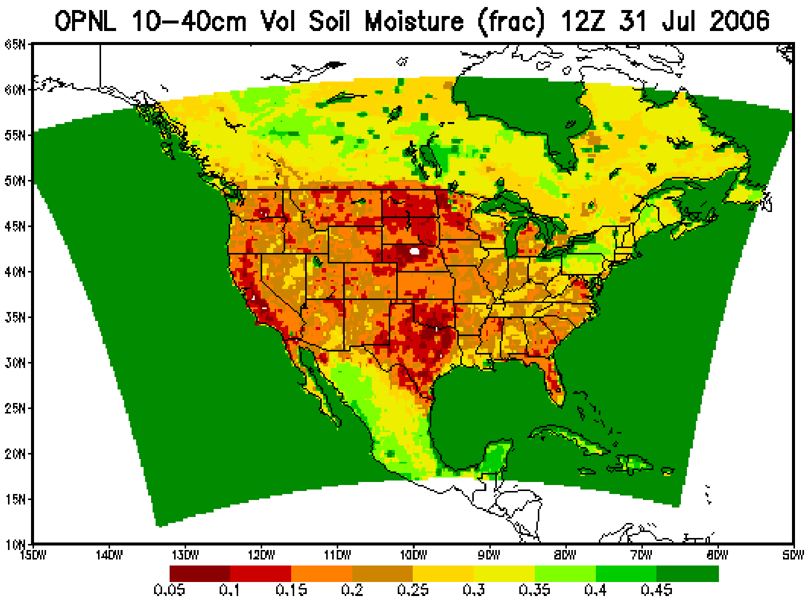
When/where hourly precipitation analysis is not available, or when it is snowing (large low bias in hourly obs), model precip during NDAS is used as driver for soil moisture --- but this has HIGH bias.

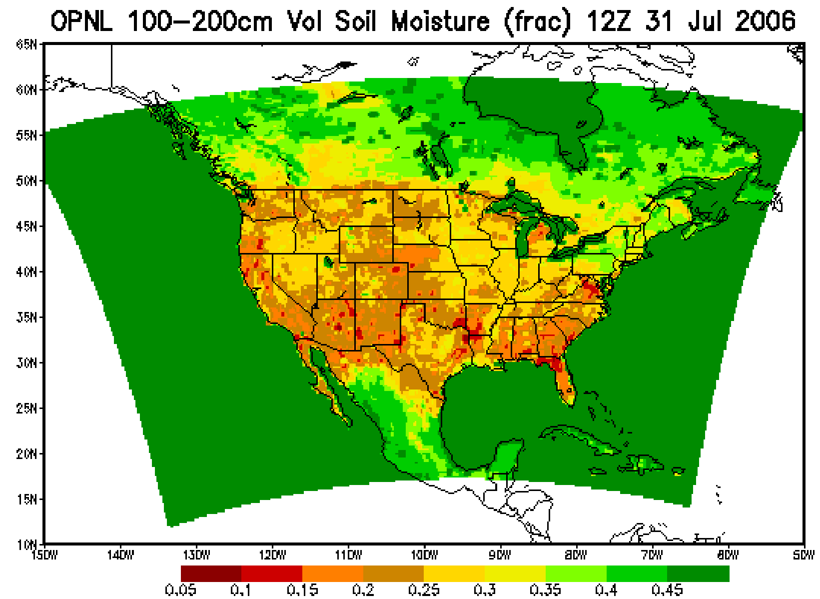


Soil Moisture, 12Z Jul 2006

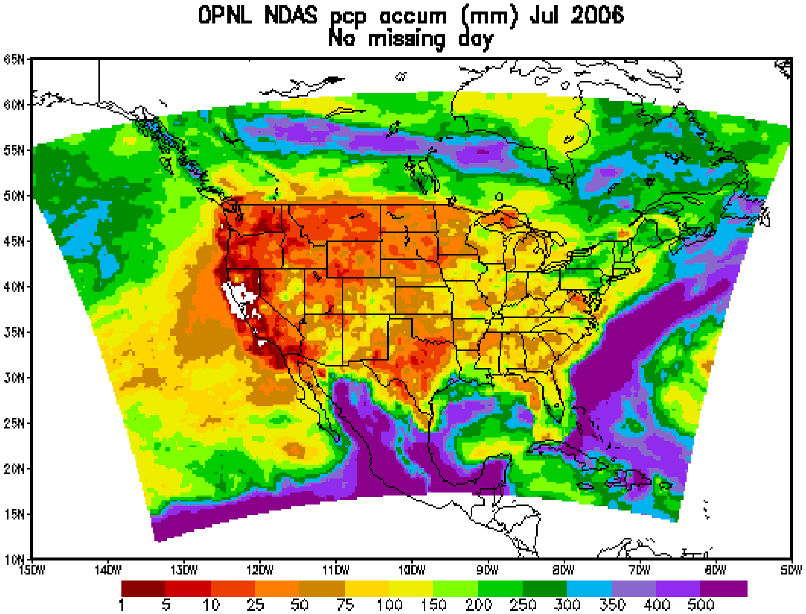


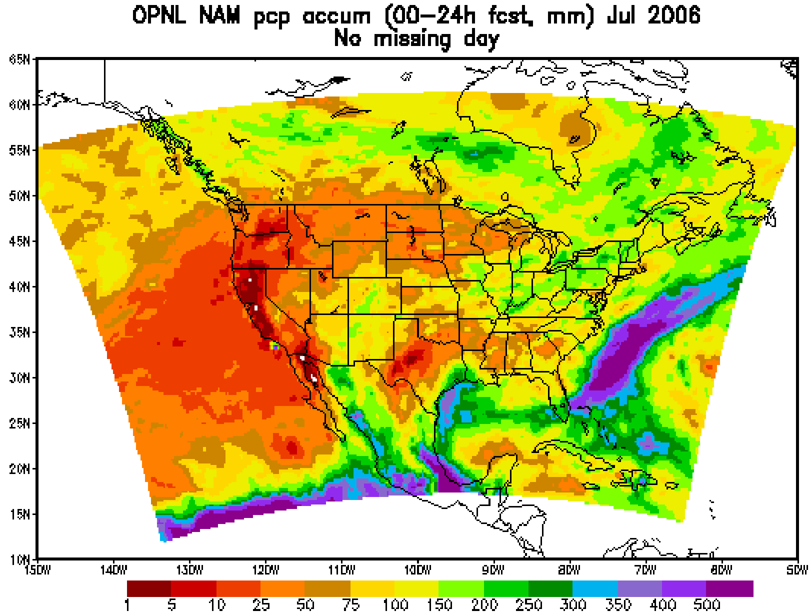


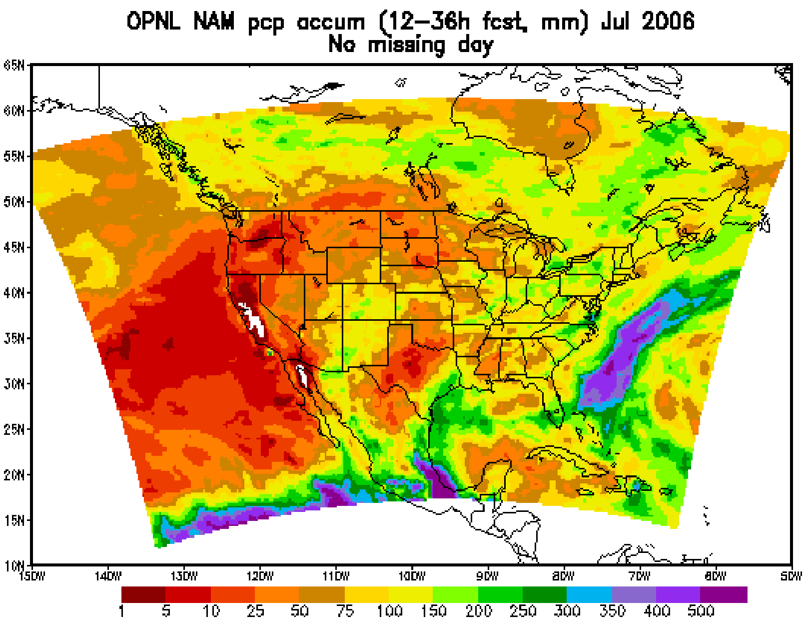




Alternative for OConUS Soil Moisture Driver







Plan to use 00Z cycle's 12-36h forecast to fill in gaps (mostly outside of ConUS) in hourly precipitation analysis input

Impact of AIRS data

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

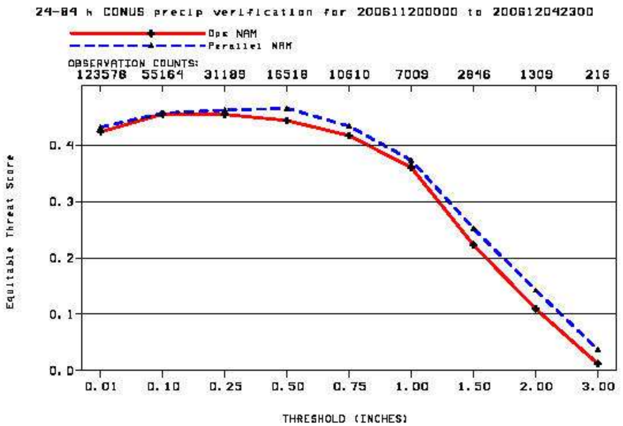
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1

cntl t
airs t

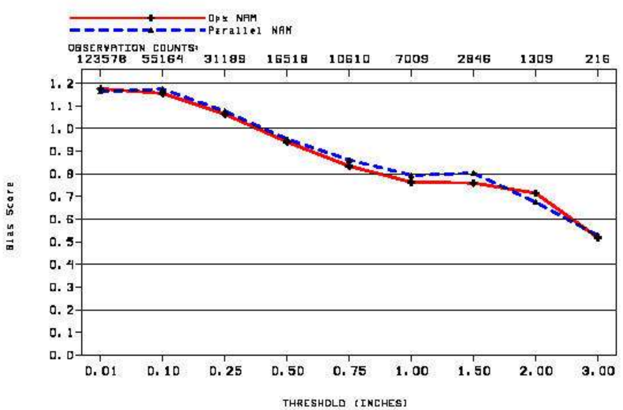
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3

cntl u
airs u

1.45
1.4
1.35
1.3
1.25
1.2
1.15
1.1
1.05
1
0.95

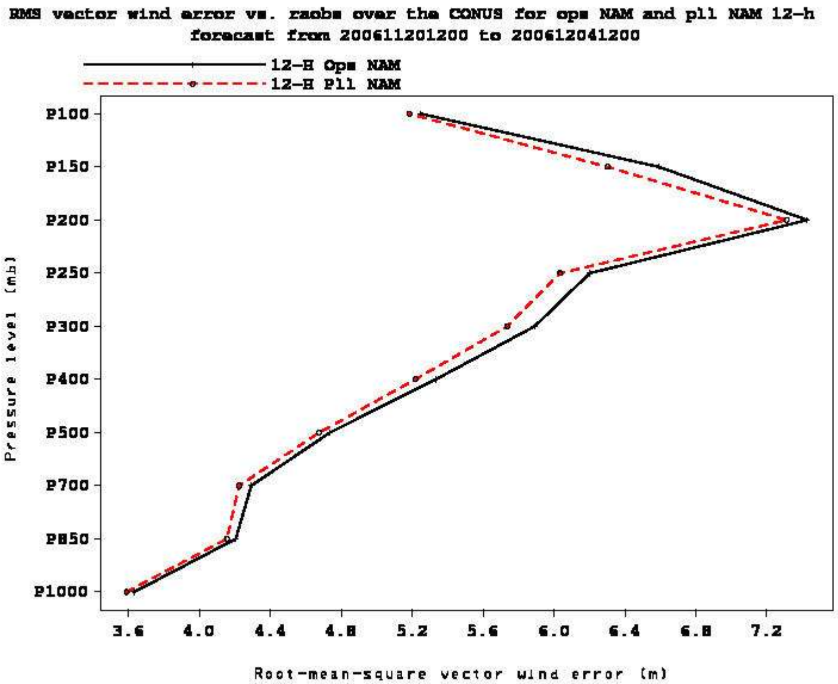


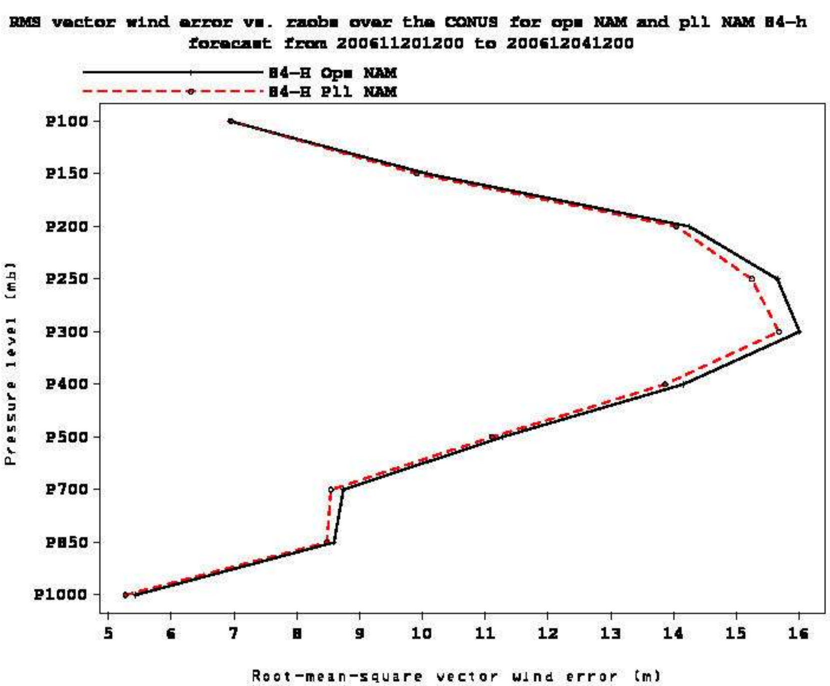
cntl q
airs q



2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3

cntl v
airsv





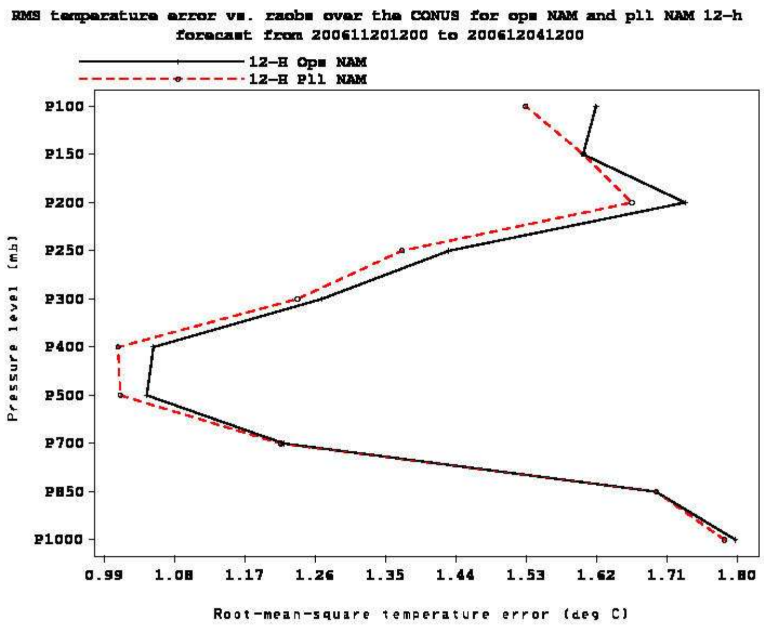
Positive impact on wind through 84 hr forecasts. Consistent with the cycling results

2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3

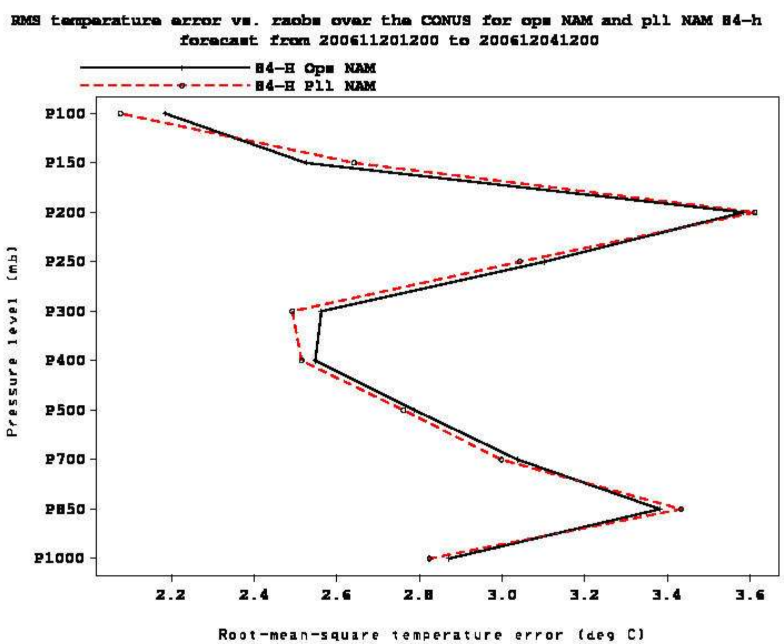
cntl v
airsv

2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3

cntl u
airs u



Positive impact on temp in first guess (3hr forecasts) in NDAS. The advantage lasts through 12 hr forecasts but become neutral by 84 hours.



1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1

cntl t
airs t

June 2007 upgrade of GSI

- Strong dynamic constraint
- Ability to assimilate GPS bending angles
- Data reported with height use height, not pressure in the forward mode
- nonlinear QC
- Change of analysis variable from Ln(ps) to ps
- Ability to utilize multiple guess files; FGAT: first guess at observation time
- extend mpi-io capability to more data input
- Use sensible temperature directly if no valid q obs

New balance method in GSI
David Parrish

- Problems with current weak constraint
  - Poor convergence of analysis iterations
  - Significant degradation of fit to observations
  - Large negative impact in first test with NAM
- New strong constraint
  - By adding NNMI to forward model, analysis increment is always in good dynamic balance.
  - Convergence of analysis still good
  - Ability to adjust background/obs errors over wider range to tune for optimal performance
  - Same cost as weak constraint J_C

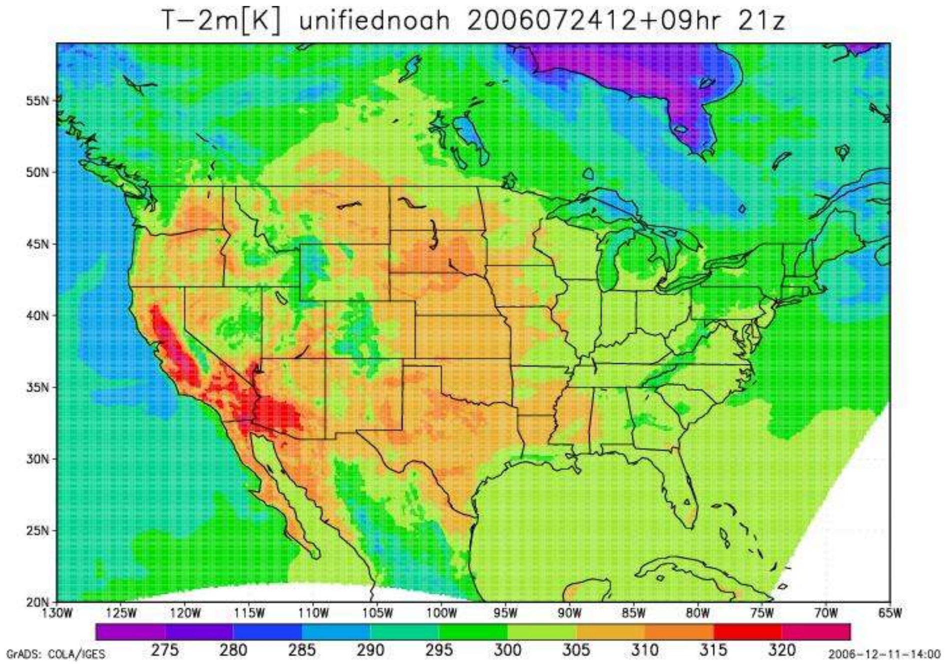
WRF-NMM unification of "Noah" land-surface model with NCAR

(single option: sf_surface_physics = 2)

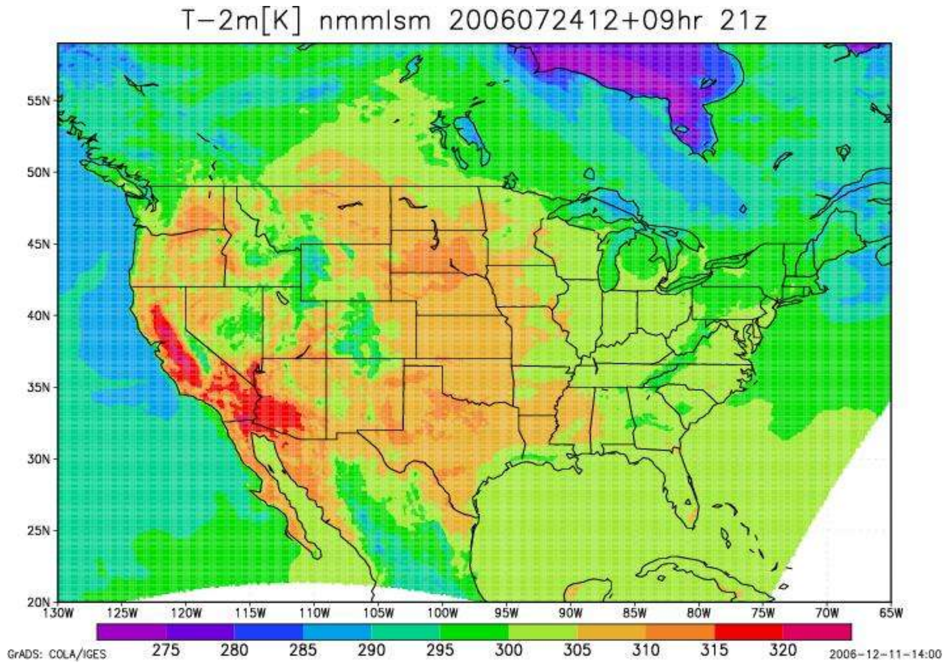
- some changes to cold season physics, minor changes to other parameters, and passing total incoming/net radiation

- *mid-day 2-m air temperatures* ***nearly identical*** *for test case: 24-JULY-2006/21z (+09-hour forecast from 12z init)*

"nmmlsm"

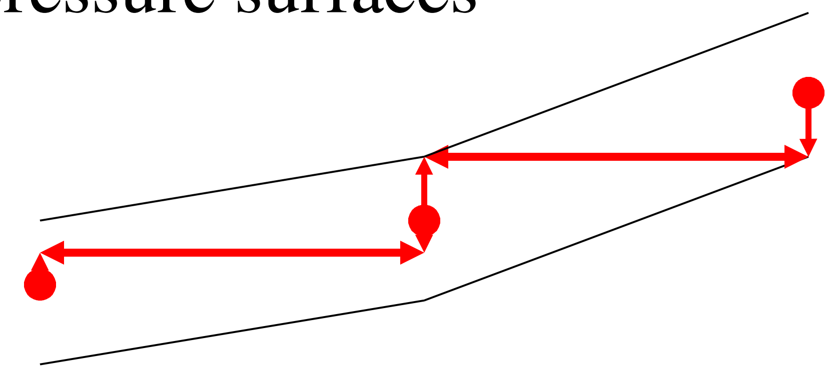


"unified-noahlsm"



Lateral diffusion on sloping surfaces

- Divergence on sloping surfaces of fluxes on constant pressure surfaces



  - Cancellation of fluxes, conservation possible
  - Acceptable with UKMO slope criterion
  - Extra cost, but not excessive

Convective Momentum Transport

- Physical model consistent with BMJ concept
  - Reference profiles for u and v
  - u and v relaxed toward reference profiles
  - Momentum conserved
- Reference profiles
  - Momentum well mixed between cloud base and freezing level (analogously to temperature)
  - From freezing level, reference values gradually tend to undisturbed values at the cloud top
- Single tuning constant

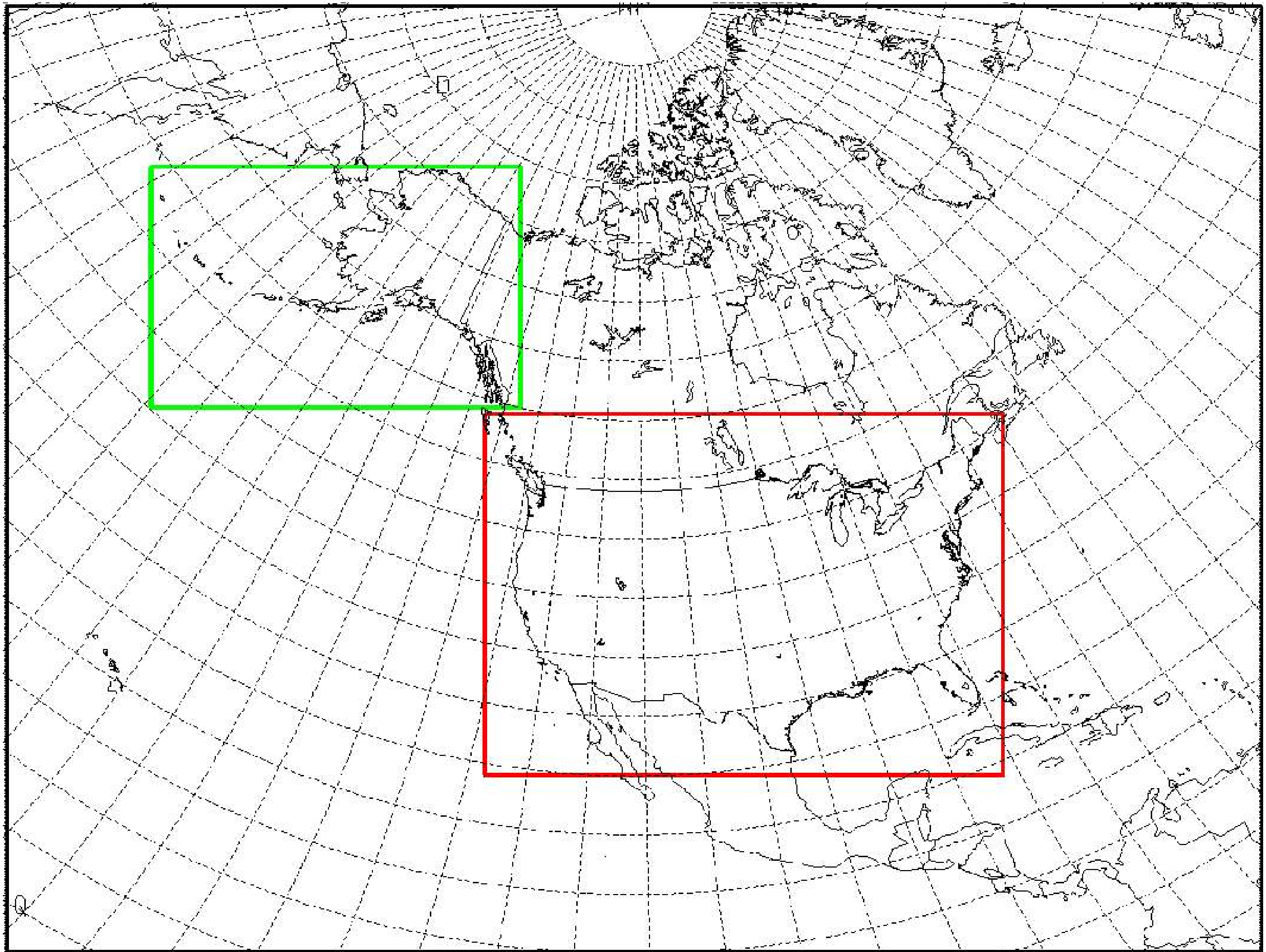
GFS Mountain Blocking and Form Drag

- Mountain blocking of wind flow around sub-gridscale orography is a process that retards motion at various model vertical levels near or in the boundary layer – follows Lott & Miller (1997) with minor changes and including the dividing streamline.
- Gravity wave drag (Form Drag) scheme in the GFS follows the work of Alpert et al., (1988, 1996) and Kim and Arakawa (1995).

NAM Plans

- Current new machines (dew/mist) 2007-2008
  - Physics tuning (unification with GFS?)
  - Expansion of domain by ~22%
- Next machine (providing ~5x blue/white) 2009-2010
  - Parent run is 12 km with all its normal NAM products out to 84 hr
  - Add 4 km nests over CONUS and Alaska run to 48 hours only
  - Nested fields available ~3 hours earlier than HiResWindow
  - 4 km output grids would be additional to existing NAM 12 km suite

Future 4 km Nests Imbedded in 12 km NAM



Other Projects

- DTRA / dispersion (McQueen)
- Verification implementation & unification
- Aviation products for ICAO
- Transition of FAA AWRP algorithms to NCEP's CCS